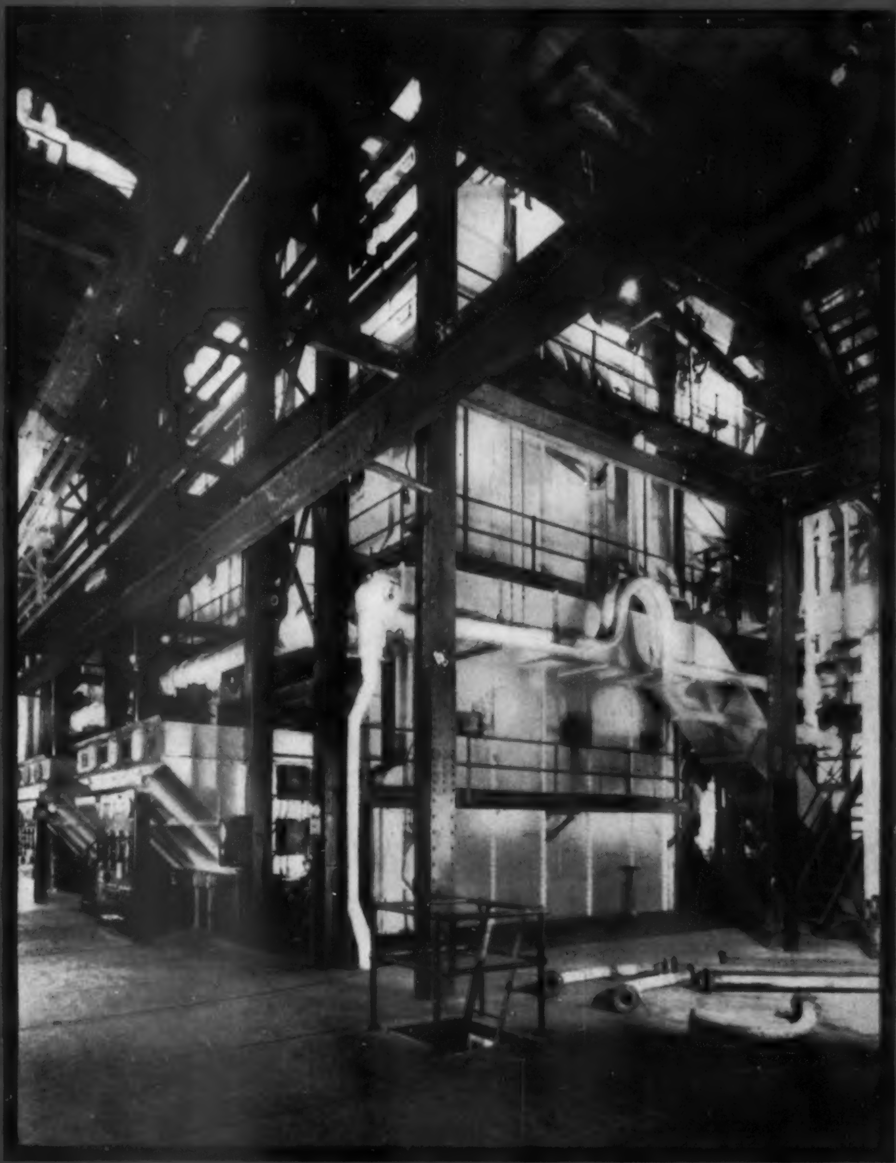
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

. 6, No. 9 MARCH, 1935 25c a copy



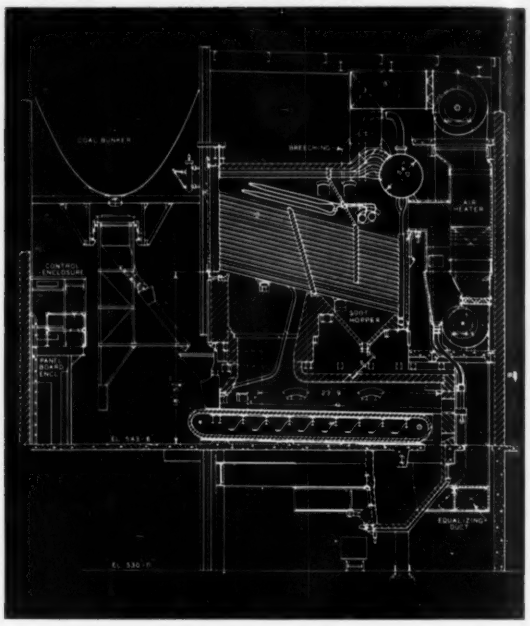
New pulverized-coal-fired units in Cos Cob Station

Cinder and Fly-Ash Measurements

The Benson Boiler and Its Application

High Efficiency - High Capacity High Availability

Marks Operating Record of Latest of University of Texas Steam Generating Units



Side elevation of boiler and Stoker. Maximum continuous capacity, 75,000 lb. of steam per hour. Unit has quadruple the capacity of old units per sq. ft. of floor space.

A large building program at the University of Texas made necessary a new steam generating unit capable of operating efficiently with Texas lignite.

A Combustion Engineering 725 hp. sectional header boiler with fusion welded drum, C-E (Coxe) traveling grate stoker, C-E plate type air heater and Elesco superheater were installed; the complete unit being placed in service in September, 1933. The unit was designed to carry a maximum load of 75,000 lb. of steam per hour continuously. An evaporative test made in March, 1934, showed 77.6% combined efficiency of boiler, superheater, air heater, furnace and stoker, when burning lignite with a heating value of 7409 B.t.u. and 35.12% moisture.

During the heating season, day load reaches peaks of 60,000 lb. of steam per hour, while night load frequently does not exceed 15,000 lb. per hour, for 5 or 6 consecutive hours; yet, notwithstanding, operating efficiencies have closely approached test figures. Plant records show an average evaporation of 8.32 lb. of equivalent evaporation per pound of dry lignite. Since installation practically no trouble has been experienced and very few adjustments made.

Whatever the fuel, capacity, space limitations, steam pressure and temperature, load fluctuations, or other characteristics involved in your individual steam generating problem, the completeness of the Combustion Engineering line of equipment and the breadth of C-E experience in helping others to solve such problems for all types and sizes of steam plants, can adequately assist you and your consultants to meet your requirements to best advantage from all points of view.

C-E Sectional Header Boiler at the University of Texas, Austin, Texas

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME SIX NUMBER NINE

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FOR MARCH 1935

FEATURE ARTICLES

EDITORIALS

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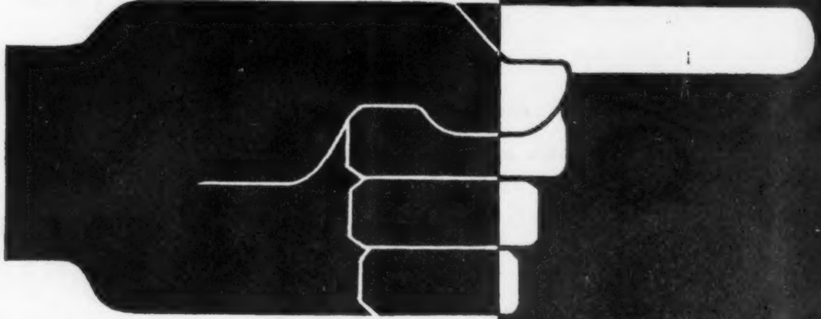

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EDITORIAL

Steam Conditions and the Prime Mover

Higher steam temperatures are gaining wide acceptance, as did high steam pressures a few years back, and their use has been fully justified in several large installations where conditions warranted. However, there is always the possibility that the "follow the leader habit," occasionally evident among American engineers, may result in applications not justified from an economic standpoint in the smaller plants. This is particularly true with reference to the prime mover, as was pointed out by W. T. Manning at the Annual Meeting of the Technical Association of the Pulp and Paper Industry.

Stating that twelve or fourteen hundred pounds pressure and nine hundred degrees present no particular difficulties for turbines in excess of ten thousand kilowatts capacity, the speaker cautioned that extreme conditions of pressure and temperature are not warranted from an economic standpoint for some types and ratings, inasmuch as the design necessary to give the required efficiency frequently results in too costly a machine.

"The problem of higher steam pressure," he said, "resolves into that of handling small volumes of steam efficiently. This becomes more difficult the smaller the rating and the higher the pressure, and makes the installation of small capacity machines for high pressures difficult for a purchaser to justify." High temperatures result in more difficult design problems than high pressure.

The remarks of Mr. Manning warrant thoughtful consideration by engineers engaged in laying out small or medium-sized installations. Each industry and in fact each plant presents its individual problem to the end that the best economic efficiency may be obtained.

Ages of Steam Boilers

On page 33 of this issue is a brief review of a recent survey covering the number, types and ages of steam boilers in Prussia. It is of interest to compare this with the results of a similar survey of industrial boiler plants recently made by *Power*.

Some striking similarities in the ages of boilers of comparable types, as well as some marked contrasts in practice, are noted. While the German survey covered nearly nine thousand boilers of all types and presumably represented a complete coverage for Prussia, the *Power* survey was necessarily more restricted and did not include many of the smaller plants where a higher percentage of obsolete equipment might be expected. It covered, however, nearly three thousand boilers of the water-tube and the fire-tube types in four hundred and fifty-four plants, representing about nine per cent of the horsepower as enumerated by the U. S. Census of Manufacture and including the principal industries. Therefore, despite its limitations, it may be taken as a fairly indicative cross-section of industrial boiler plant practice in the United States.

As to preponderance of type, there is a marked difference between the two countries. Water-tube boilers represented only seventeen per cent of the total number in Prussia, although accounting for over fifty per cent of the heating surface; whereas in this country, water-tube boilers represented nearly seventy-three per cent of the total and eighty-six per cent of the heating surface.

From the standpoint of age, there is much closer agreement; in fact, in certain ranges the figures for the two countries are almost identical. For instance, in Prussia 24.3 per cent of the water-tube boilers fall within the ten-year class, and in this country 24 per cent of those reported are from one to ten years old. Again, in Prussia 65.5 per cent of the water-tube boilers fall within the twenty-year class and in this country the percentage is 64. In both countries there is an appreciable number still operating after thirty years.

The similarity is not so marked in the case of fire-tube boilers. In Prussia nearly sixty per cent are from twenty to thirty years old, nineteen per cent are from ten to twenty years old, and only five per cent are less than ten years old; whereas the corresponding figures for this country are twenty, thirty-six and forty-four per cent.

While both surveys attest to the long physical life of boilers as a major item of power plant equipment, they fail to reveal anything as to their economic life. In the light of advances in power plant practice during the past ten or fifteen years, it is likely that the high percentage of boilers in the twenty-year class and older have long outlived their economic usefulness.

Registration of Engineers

The extent to which the registration of professional engineers has grown is indicated by the fact that twenty-six states now have such laws on their statutes and legislation to this end is being actively promoted in seventeen more, including Massachusetts, through the efforts of the National Society of Professional Engineers with the backing and cooperation of numerous national and local engineering bodies.

It is probably not generally known that the first state to require the registration of professional engineers was Wyoming in 1907. Another followed in 1912 and the number was considerably increased in the early twenties. Of late the movement has received added impetus through an awakened realization that the status of the engineer can best be raised by giving official recognition to those qualified.

There are now approximately forty-five thousand professional engineers registered in the twenty-six states, of which New York accounts for about ten thousand. The depression has undoubtedly prevented many who are qualified from seeking registration. With a return to normalcy and the extension of licensing to other states this figure is expected to be greatly augmented.

Fig. 1—A difficult place to sample cinder and fly ash fifty feet above the roof

CINDER and FLY-ASH Measurements

By P. H. HARDIE, Test Engineer, Research Bureau, Brooklyn Edison Company, Inc.

A description of the method and apparatus developed by Research Bureau of the Brooklyn Edison Company for investigating the effectiveness of different types of dust separating equipment. While all the investigations were conducted on stoker-fired installations, the procedure is equally applicable to pulverized coal installations.

WITH the development of the modern coal-fired power plant during the last ten to fifteen years, the vital importance of reliable instruments and test methods for obtaining data on all phases of plant operation has been realized. Much of the recent development has been concentrated in the boiler room. Cinder and fly-ash measurements have served as a guide in improving the boiler efficiency by indicating means of reducing the flue dust loss, and have also aided in the development of efficient dust separating apparatus. It is generally appreciated that the determination of the dust content of flue gas is one of the most difficult measurements that confronts the test engineer. Since no standard practice exists, each investigator has had to rely almost entirely upon his own ingenuity with but little help from technical literature.

These investigations of cinder and fly ash are usually conducted for one of the following three purposes:

1. To determine the amount of dust leaving the stacks.
2. To determine the efficiency of the dust separating apparatus.
3. To determine the loss in steam-generating unit efficiency due to solid combustibles carried up with the flue gas.

The test apparatus and testing technique required for these three investigations are essentially the same. Briefly, the test procedure consists in sampling the gas for dust concentration at a sufficient number of points in a cross-section of the gas passage to obtain the average dust concentration. The dust concentration, in pounds of dust per pound of gas, multiplied by the total gas flow gives the total quantity of dust passing the section. Gas flow can be determined from flue gas and fuel analyses and weight of fuel burned, or from a pitot-tube traverse.

In testing dust separating apparatus it is not necessary to determine the rate of gas flow if the efficiency only is required since the efficiency can be determined from the dust concentration at the inlet and outlet. The efficiency, of course, can be determined using either of these measurements together with a measurement of the weight of dust caught and gas flow. Wet-type dust separating apparatus, however, precludes this latter procedure, and even with dry separators the problem of removing the dust for weighing is a difficult one and may upset the normal operation of the separator by allowing air to flow up through the discharge line.

A number of different types of dust concentration samplers have been developed and used with varying degrees of success depending on the conditions under which the tests were made. An approximately straight section of duct, in which to install the samplers, is essential for all types. Other factors are size of dust particles, temperature of the gas at the sampling points and the wetness of the gas and dust particles.

An extensive investigation of the effectiveness of different types of dust separating apparatus carried on over a number of years by the Brooklyn Edison Company, Inc., has resulted in the development of a dust concentration sampler (cinder sampler) which has proved very reliable and relatively easy to operate. With this apparatus an adequate number of samplers can be used without undue cost in test personnel. All the investigations were conducted on stoker-fired installations but the test equipment and procedure are equally applicable to pulverized fuel installations where the fly ash particles are all very small.

Cinder-Sampling Equipment

Fig. 2 is a sketch showing the cinder-sampling equipment and its general arrangement. For simplicity, only one sampler and measuring orifice are shown but Figs. 3 and 5 show the grouping of both samplers and orifices. A small part of the cinder-laden gas is intercepted by the one-inch sampling tube facing into the stream and is drawn into a wool filter bag attached to the other end of the tube and incased in a glass jar. The cinders are retained in the bag and the gas passes on to the control valve, $^3/_8$ in. monel metal measuring orifice and steam siphon. A water manometer connected across the orifice serves the dual purpose of indicating the gas flow rate

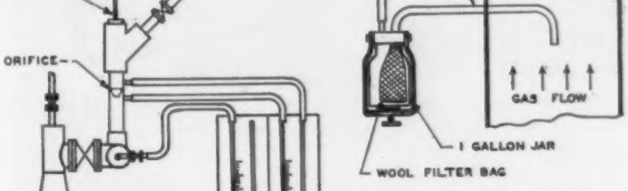


Fig. 2—Arrangement of cinder-sampling apparatus
(For simplicity only one sampler is shown)

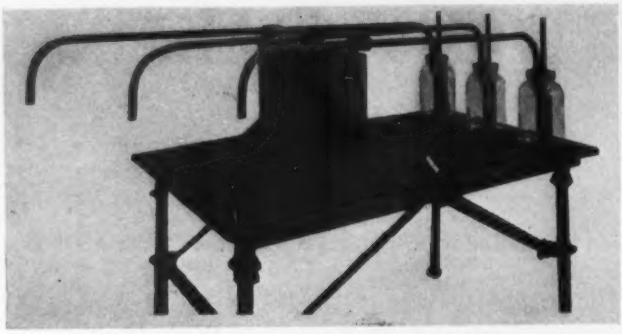


Fig. 3—Samplers of different lengths showing the way they are arranged in a duct

(The monel screens inside the jars are used where the gas temperature is high. The jars in this picture are screwed on the samplers. However, the yoke method of fastening, shown in other figures, is recommended.)

and guiding the operator in regulating the flow. A mercury manometer is used to indicate the discharge pressure. The rate of gas flow through each sampling tube is regulated to give a velocity through the tip equal to the gas velocity in the duct at the position where each tube is spotted. This velocity is determined by pitot-tube and thermocouple traverses made just prior to the test and after the desired operating conditions have been obtained.

The filter bag is attached to the sampling tube by means of a ferrule having a bayonet type fastener as shown in Fig. 4. A loosely woven wool cloth of medium weight, obtainable at any department store, has been used for these bags. They are made by cutting the cloth in strips 10 in. wide, sewing the seams the full length with linen thread and then cutting in lengths of $10^1/_2$ in. The bottom edge of the bag is hemmed to prevent the bottom from being blown out, and the longitudinal seam is reinforced with paper-fastening staples to prevent bursting. This type of bag has been used for temperatures up to 425 F., but the life of the bags was shortened considerably.

When temperatures in excess of 425 F are encountered it is necessary to use monel metal basket-type screens attached to the outlet connection of the glass jar as shown in Fig. 3. A close fitting spring inside prevents these screens from collapsing. The screens are 100 mesh which allows a small quantity of fine cinders to pass before the holes are filled with larger particles, but the

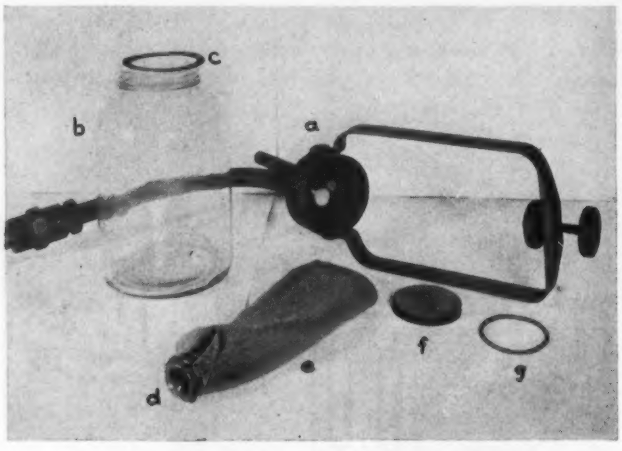


Fig. 4—Details of cinder sampler

(*a*—Outlet end of sampler, *b*—one gallon jar, *c*—gasket, *d*—ferrule for attaching filter bag to sampling tube by means of the bayonet type fastener, *e*—wool filter bag, *f*—bakelite bottom for filter bag, and *g*—spring belt for holding the bag in the groove in the bakelite bottom.)

error introduced becomes small when tests of two hours' duration or longer are made. The resistance of the screens builds up to a higher value than that of the bags and therefore requires a vacuum of 15 in. of mercury, whereas, 8 in. has been found to be sufficient when bags are used.

In those cases where wet gas and cinders are encountered, apparently the only satisfactory procedure is to bubble the gas through water, then filter the water at the end of the test and dry the cinders.

A manometer board similar to the large one having twelve U-tubes, shown in Fig. 5, has been found to be quite handy for the nozzle differential pressures. The scale is ruled all the way across the board with the zero at the bottom, and the U-tubes slide so that the lower water legs can be set at zero regardless of the individual deflections. With this arrangement, once the manometers are adjusted, the operator can tell by a glance at the

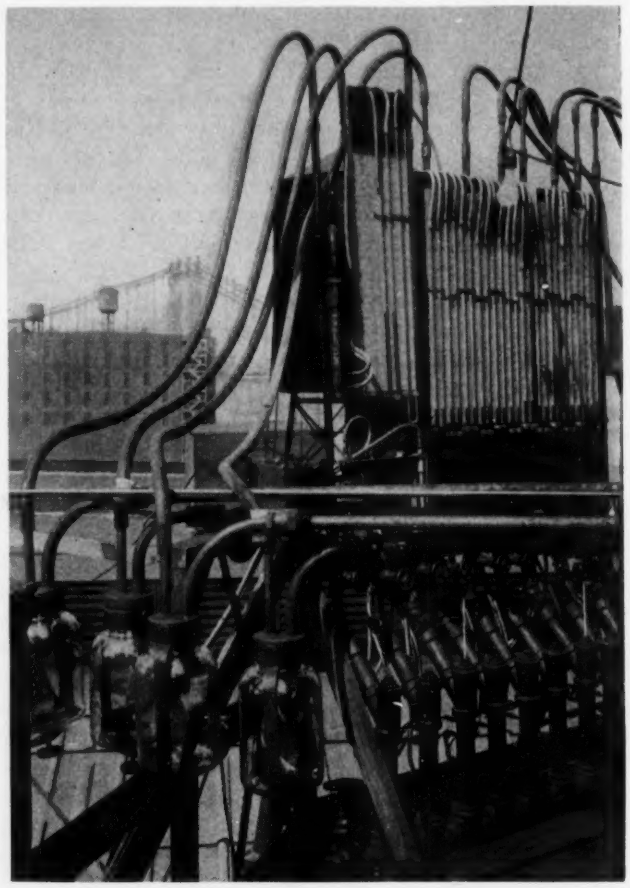


Fig. 5—Cinder-sampling equipment installed on a stack

zero line whether all manometers have the correct setting. He, also, can regulate quickly by means of the control valves any that are off without the necessity of first knowing what the respective differentials should be.

This apparatus is designed for operating with a constant and equal discharge pressure from all orifices, controlled by means of the large valve at the left in Fig. 5, and indicated on the mercury manometer above. This arrangement has been found to be advantageous because the increasing resistance of the filter bags may be offset by gradually opening the individual control valves as required without changing the density of the gas at the orifices.

With the usual arrangement of having the control valves on the discharge side of the orifices, the correct orifice manometer deflections cannot be determined until after the test has been started and the separate discharge pressures for each orifice have been read. The discharge pressures, however, are in their turn dependent upon the orifice manometer deflections (rates of flow), and thus the starting of a test is difficult and the probability of errors is great. Further difficulty will be encountered because the change in density of the gas at each orifice with increase in resistance of the filter bag necessitates a continual increase in orifice manometer deflection if a constant mass flow is to be maintained.

The number of cinder-sampling tubes required depends on the size of the gas passage, the variation in gas velocity and dust loading across the section. For the large units at the Hudson Avenue Station, twelve samplers for the ducts and twenty-four for the stacks have been found to be adequate. The method of dividing the cross-sectional area of the ducts and stacks for spotting the samplers is shown in Fig. 6.

An example of a difficult place to sample is shown in Fig. 1 where it was necessary to go a distance of about fifty feet above the roof to avoid the turbulence at the flue entrances. A close-up of part of the test equipment mounted on the platform is shown in Fig. 5.

One of the applications of this sampling method to the determination of the cinder loss during a steam-generating unit efficiency test is described in a paper entitled, "The Test Performance of Hudson Avenue's Most Recent Steam-Generating Units" *A. S. M. E. Trans.*, Nov. 1934, FSP-56-15.

Preparation and Operation

The procedure described below should be followed in preparing for and operating the test equipment.

1. Select the location for installing the samplers in a straight portion of vertical duct. In the case of a stack test install samplers at least two diameters above the flue entrances.

2. Decide on the number of samplers to be used and distribute them similar to the method shown in Fig. 6.

3. Test the equipment for leaks by first inserting rubber stoppers in the sampling tubes where the filter bags attach. Then with bottles in place and control valves open, turn on the siphon. Any appreciable leak will be indicated by a deflection of the differential manometers of those lines in which leaks exist.

4. Calibrate the orifices with a *standard* orifice using the arrangement shown in Fig. 8, and follow the procedure outlined under "Curves for Orifice Calibration." Be sure the orifices are clean.

5. With the steam-generating unit operating at the test load, make a pitot-tube and thermocouple traverse at the points at which the samplers are spotted.

6. From the velocity heads and temperatures the manometer deflection to be held on each orifice is obtained from Fig. 7. Slide the U-tubes to a position such that the top of the water will be at a position on the scale equal to one-half the respective deflections. This will facilitate regulating the flows when the test is being started.

7. To start the test, open the main control valve in the discharge manifold until the desired pressure (8 in. Hg) is obtained, and at the same time regulate the individual control valves to bring the lower legs of all the manometers to zero. After the flow conditions have become steady, check the manometer deflections and make minor adjustments if found necessary.

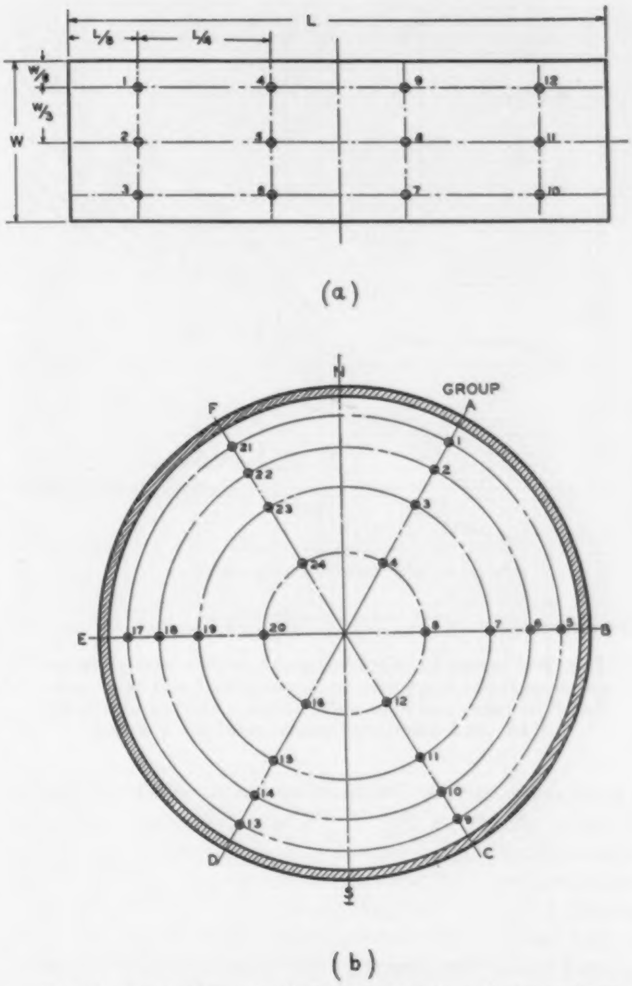


Fig. 6—Typical methods of distributing the samplers so that they will be spotted at the center of equal areas
(*a*—Flue or gas duct, and *b*—stack.)

8. Record the gas temperature at the orifices at regular intervals throughout the test. One thermometer for each group of three or four samplers is adequate.

9. Should trouble occur, such as the bursting of a bag or the choking of a bag from the accumulation of cinders, shut down all samplers with the main control valve, change the bag causing trouble, and record the outage time.

10. Make the test of a duration such that a sufficient amount of cinders or fly ash is caught to be accurately weighed. It should also be of sufficient length to minimize the effect of normal fluctuations in test conditions. Test runs should be not less than one hour and preferably three hours in duration.

11. At the end of the run remove the bags and weigh the cinders or fly ash in each separately if the variation in dust concentration for the different positions is desired. However, if only the average dust concentration is needed, the contents of all bags can be weighed together.

12. Compute the dust concentration by dividing the weight of cinders or fly ash caught by the pounds of gas sampled during the test.

The proper setting of each of the orifice manometers after making the pitot-tube and thermocouple traverses

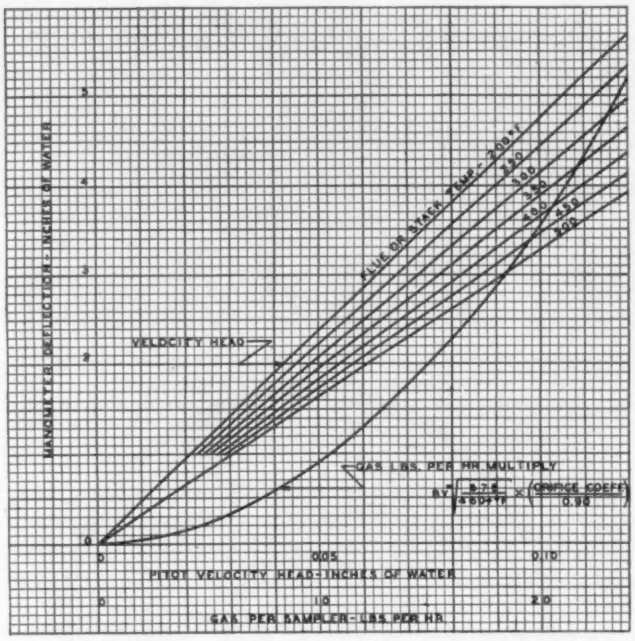


Fig. 7—Curves for obtaining the orifice manometer settings from the pitot-tube velocity head readings. Gas flow rates are also obtainable. Orifice diameter 3/8 in. and discharge pressure 22 in. Hg Abs

is most conveniently obtained by means of curves similar to those shown in Fig. 7. The manometer deflection versus velocity head curves were constructed on the assumption that the velocity of the gas at the tip of the sampler tube is to be equal to the gas velocity in the duct at that point. The corresponding flow of gas was then equated to the flow through the orifice and the manometer deflection was expressed in terms of the velocity head reading from a pitot tube. The equations on which the curves are based are developed below:

Let W_s = Gas flow into sampler, lb/sec
h_1 = Velocity head, ft of gas
d_1 = Duct gas density, lb/cu ft
0.0044 = Inside area of sampler tube, sq ft

Then $W_s = 0.0044\sqrt{2\,gh_1} \times d_1$

Let W_0 = Gas flow through orifice, lb/sec
0.000767 = Orifice area, sq ft
0.90 = Coefficient of discharge (assumed)
h_2 = Orifice differential press, ft of gas
d_2 = Density of gas at orifice, lb/cu ft

Then $W_0 = 0.000767 \times 0.90\sqrt{2\,gh_2} \times d_2$

Converting feet of gas into inches of water, let
H_1 = Velocity head, inches of water
H_2 = Manometer deflection, inches of water

$$h_1 = \frac{62.4}{12} \times \frac{H_1}{d_1} = 5.2\,\frac{H_1}{d_1}$$

$$h_2 = \frac{62.4}{12} \times \frac{H_2}{d_2} = 5.2\,\frac{H_2}{d_2}$$

Substituting and equating

$$W_s = W_o, \text{ or } 0.0044\sqrt{H_1 d_1} = 0.000690\sqrt{H_2 d_2}$$

The gas density

$$d = \frac{144 \times p}{50.5 \times T \times 2.036} \text{ where}$$

p = Abs gas pressure, inches of mercury
T = Abs gas temperature
= 460 + deg F.
50.5 = Gas constant for typical flue gas

$$\text{Hence,} \quad H_2 = \left(\frac{0.0044}{0.000690}\right)^2 \times \frac{p_1\,T_2}{p_2\,T_1} \times H_1$$

$$= 40.6\,\frac{p_1\,T_2}{p_2\,T_1} \times H_1 \text{ where}$$

p_1 = Pressure at sampler tip = 29.8 in. Hg abs (assumed)
p_2 = Pressure at orifice = 22 in. Hg abs
T_1 = Abs temp of gas in duct, 460 + deg F
T_2 = Abs temp at orifice, and is assumed to be 575, (115 F)

Substituting in the preceding equation

$$H_2 = 31{,}500 \times \frac{H_1}{T_1}$$

For any given value of T_1 the relation between the velocity head and the manometer deflection is linear. The chart is for a low range of manometer deflections and was constructed for $T_1 = 660$ to 960, (i. e. 200 to 500 F) in 50-deg steps.

The gas flow per sampler may be found in terms of the manometer deflection by referring to a preceding equation, viz;

$$W_o = 0.000767 \times 0.90\sqrt{2gh_2} \times d_2 \text{ lb/sec}$$

$$\text{or} \quad W_o' = 45.52\sqrt{H_2\,d_2} \text{ lb/hr}$$

$$d_2 = \frac{144 \times 22}{50.5 \times 575 \times 2.036} = 0.0535 \text{ lb/cu ft}$$

$$\text{Hence} \quad W_o' = 10.53\sqrt{H_2} \text{ lb/hr}$$

This relation between gas flow and manometer deflection gives the parabolic curve in Fig. 7. Since this curve is based on a temperature of the gas at the orifice of 115 F and an orifice coefficient of 0.90, found by experience to be average values, it is necessary to correct the values of gas flow read from this curve for the deviations of these two quantities.

Curves for Orifice Calibration

The coefficient of discharge of a test orifice may be found most conveniently by comparing its deflection with that of a *standard* orifice in series with it. For this purpose Fig. 8 was constructed for a test orifice discharge pressure of 8 in. Hg below atmospheric. Both test and standard orifices are 3/8 in. in diameter, and in this case the orifice used as a secondary standard had a coefficient of 0.955. The equations used in construction of the curves are given below.

Let W_2 = Air flow through test orifice, lb/sec
0.000767 = Orifice area, sq ft
C_2 = Coefficient of discharge of test orifice
H_2 = Deflection of test orifice manometer, inches of water
d_2 = Density of air through test orifice, lb/cu ft

Then

$$W_2 = 0.000767 \times C_2\sqrt{2g \times 5.2\,H_2\,d_2}$$

Similarly, letting subscript (3) represent the standard orifice conditions

$$W_3 = 0.000767 \times C_3\sqrt{2g \times 5.2\,H_3\,d_3}$$

Since the orifices measure the same weight of air

$$W_2 = W_3 \text{ or } C_2\sqrt{H_2\,d_2} = C_3\sqrt{H_3\,d_3}$$

$$\text{or} \quad H_2 = \left(\frac{C_3}{C_2}\right)^2\left(\frac{d_3}{d_2}\right)H_3$$

$$\text{Now} \quad d_2 = K\,\frac{p_2}{T_2} \text{ and } d_3 = K\,\frac{p_3}{T_3}$$

Where K = a constant
p_2 = Abs pressure of air at test orifice
p_3 = Abs pressure of air at *standard* orifice
T_2 = Abs temperature of air at test orifice
T_3 = Abs temperature of air at *standard* orifice

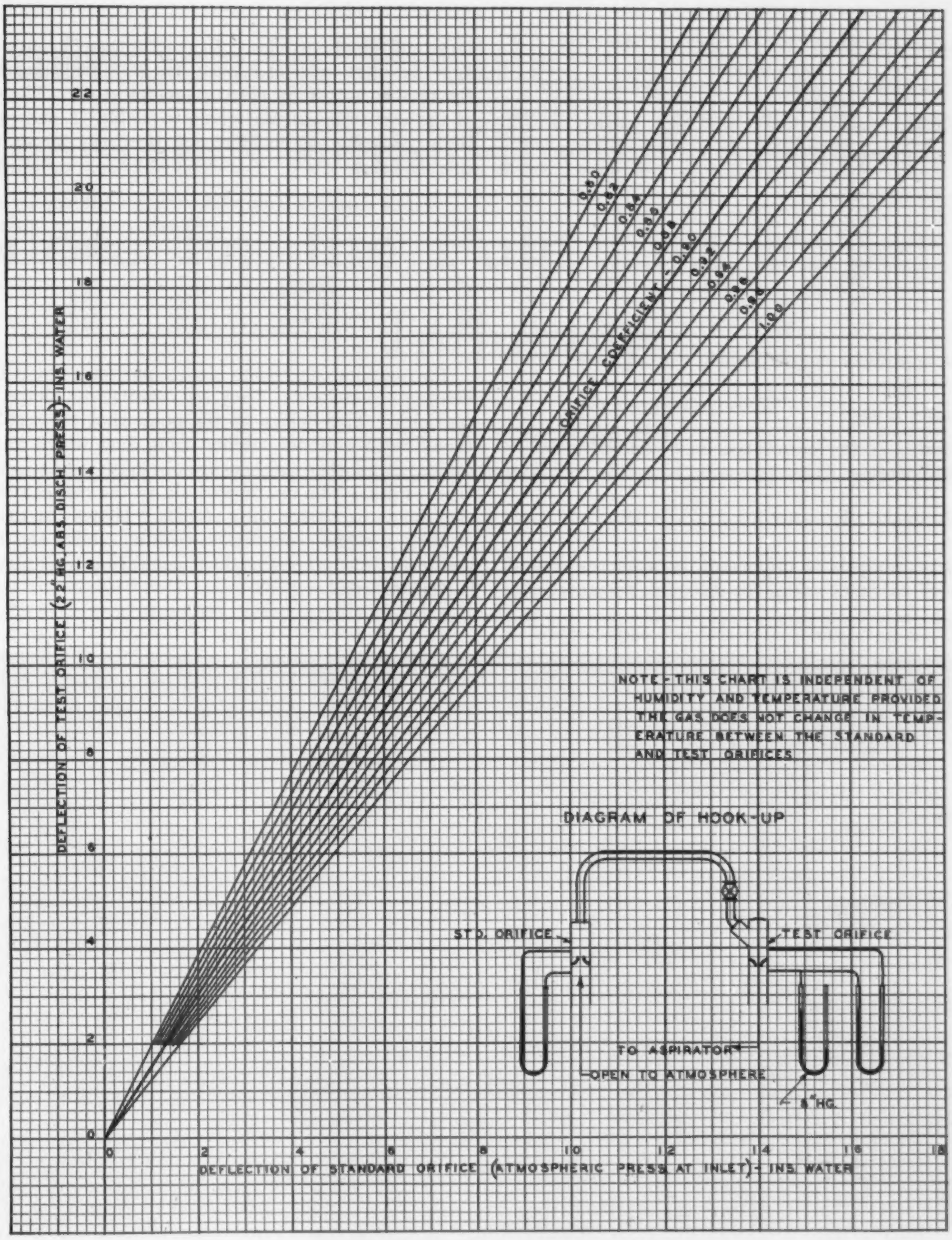


Fig. 8—Sample of curves used for orifice calibration

(In this case both the test and *standard* orifice are 3/8 in. diameter and the latter, used as a secondary standard, has a coefficient of 0.955.)

Substituting

$$H_2 = \left(\frac{C_3}{C_2}\right)^2 \left(\frac{p_3\,T_2}{p_2\,T_3}\right) H_3$$

Now if $C_3 = 0.955$

$p_2 = 22$ in. Hg abs

$p_3 = 30.0 - H_3/13.6$ (30.0 in. barometer)

$T_2 = T_3$

$$H_2 = \left(\frac{0.955}{C_2}\right)^2 \left(\frac{30 - H_3/13.6}{22}\right) H_3$$

In this final equation, values for C_2 were assumed and H_2 plotted against H_3 to give the series of straight lines in Fig. 8.

Calibrations are made using the arrangement of the *standard* and test orifices shown in Fig. 8. The deflections are measured at several flows over the range required for the test and an average coefficient used.

Typical Cinder Catcher Test Data

The results of a typical efficiency test of a wet-type cinder catcher are given in Tables I and II. The importance of using a number of samplers is indicated by the unequal distribution of the cinders.

TABLE I—TYPICAL CINDER CATCHER TEST DATA

(Length of Run 3 hr.)

	Inlet Sampling Location			Outlet Sampling Location		
Sampling Point No.	Manometer Deflection In. Water	Gas Sampled Pounds	Cinders Caught Grams	Manometer Deflection In. Water	Gas Sampled Pounds	Cinders Caught Grams
1	5.9	79.0	75	3.0	55.2	1
2	3.9	61.6	26	2.3	48.0	7
3	1.0	31.0	5	0.5	21.1	1
4	6.0	79.4	85	2.7	52.1	1
5	4.8	69.0	46	2.3	47.7	2
6	1.7	41.0	18	0.5	21.0	2
7	1.2	35.0	9	1.0	31.0	1
8	3.6	61.6	33	2.2	47.5	5
9	6.5	82.8	133	3.5	60.0	10
10	1.0	31.0	6	1.8	42.1	0
11	4.4	67.0	39	2.2	47.3	1
12	5.8	79.0	87	2.9	54.3	12
		717.4	562		527.3	43

The average dust concentration at the inlet is:

$$\frac{562}{717.4 \times 453.6} = 0.00173 \text{ lb cinders per lb gas}$$

and similarly, at the outlet the dust concentration = 0.00018 lb cinder per lb gas

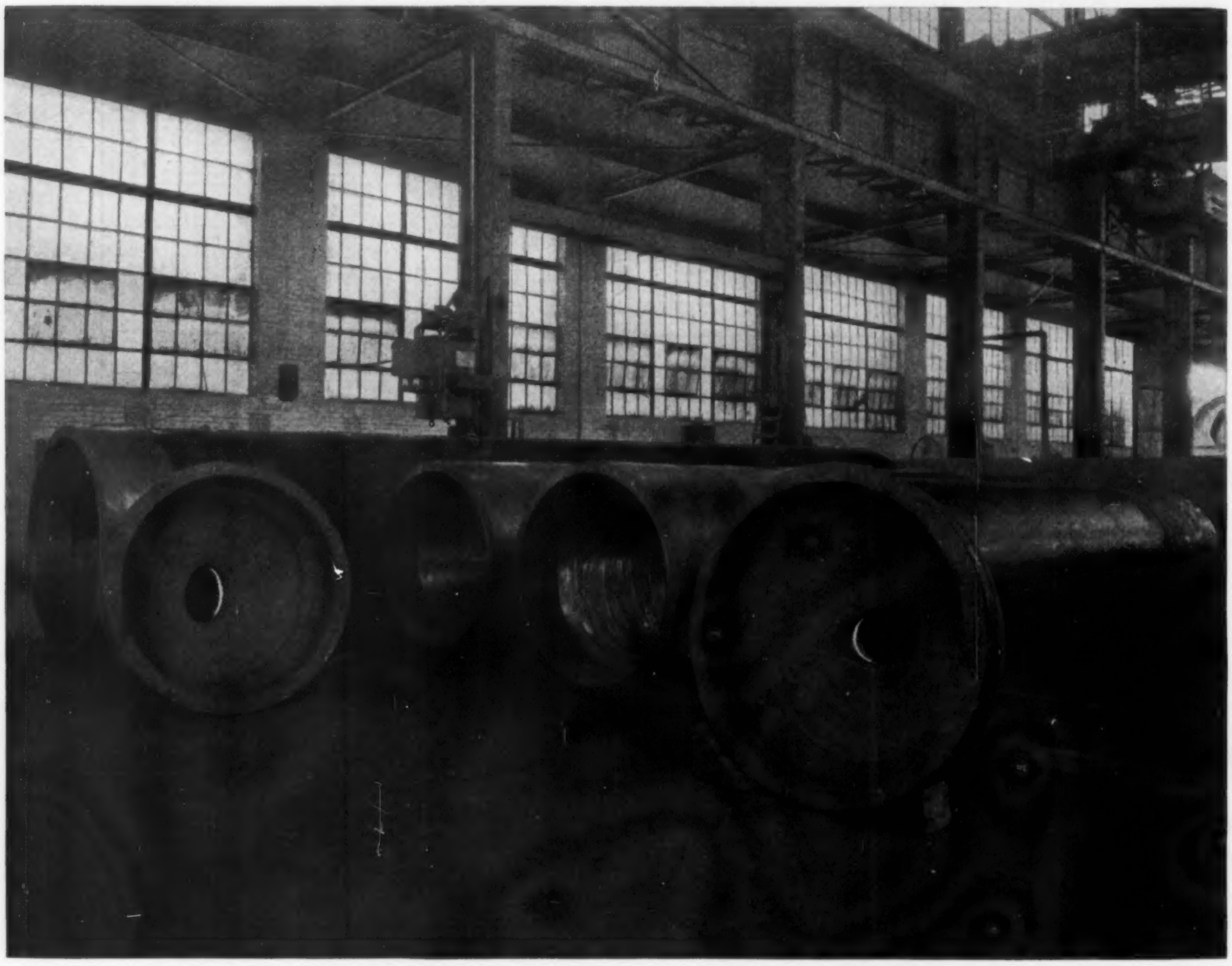
$$\text{The cinder catcher efficiency} = 1 - \frac{0.00018}{0.00173} = 90 \text{ per cent}$$

The sieve analysis is important because the overall efficiency of catchers varies for different percentages of large and small particles. In general the efficiency of dry type catchers falls off rapidly for the small sizes, while the reverse is true for electric precipitators. The results of the wet-type catcher, given in Table II, show only a slight dropping off in efficiency from the larger to the smaller sizes.

TABLE II—SIEVE ANALYSES AND EFFICIENCY BY SIZE

		Sieve Analysis		Efficiency
		Inlet Per Cent	Outlet Per Cent	by Size Per Cent
On	60 mesh	52.2	40.0	92
On	100 mesh	15.5	15.4	90
On	200 mesh	15.5	16.0	89
On	325 mesh	5.9	10.7	82
Through	325 mesh	10.9	17.9	83

Two factors other than size of particles affect the efficiency of catchers. They are density and shape of the particles. This brings up the point that the results obtained with a model catcher using dust which has been caught in another catcher, are obviously not representative results. The use of cold air on the model tests further tends to vitiate their results. Hence the necessity of using a reliable method of making cinder and fly-ash measurements after the dust separating apparatus has been installed is evident.



Shop view of drums for new 1400-lb boiler at the Ford Motor Company

Two of these drums are 48 in. diameter, 34½ ft long and 5½ in. thick; and two are 40 in. diameter, 30 ft long and 4 in. thick. The shells are forged and the heads will be welded on

Construction Problems Associated with High-Pressure Boilers for the Pulp and Paper Industry

By F. H. ROSENCRANTS
Combustion Engineering Company, Inc., New York

This paper, which was presented at the annual meeting of the Technical Association of the Pulp and Paper Industry in New York, February 19, 1935, analyzes the economics of moderately high steam pressures for pulp mills and discusses the adaptability of the box-header, the bent-tube, multi-drum and the sectional-header, straight-tube types of boiler to the high-pressure range.

THE maximum steam pressure in the pulp mill for process work is that required for the digesters and seldom exceeds 150-lb gage. The objective of higher steam pressure is power production through the medium of a high-pressure turbine exhausting at pressure requirements for process. The ideal pressure in any given instance is that pressure in combination with the steam required for process which will, when expanded through a high-pressure turbine down to process pressure, produce the amount of power required to operate the plant. The ideal steam temperature is that which will result in the steam at the exhaust from the high-pressure unit being near saturation.

Figs. 1 and 2 are idealistic but show clearly the manner of superimposing a high-pressure power production unit upon a plant requiring steam for process. As will be noted in Fig. 1, all steam is generated without superheat and at the maximum pressure required for process work. Such steam as is required at pressure lower than the generated pressure is passed through turbine equipment as indicated in the diagram. It is recognized that steam requirements will vary through rather wide limits as between various plants. The quantities of steam indicated in the diagram, however, are taken from a specific case and are the quantities per ton of pulp at the three different pressures indicated.

Fig. 2 is identical in the steam requirements for process but all steam is generated at a pressure higher than the maximum process requirement. A superheater, a high-pressure turbine, and a high-pressure feedwater heater are added. The variation in power production with increasing pressure is noted in Fig. 3. In this same figure is plotted a curve showing the total steam temperature required in order that the exhaust from the high-pressure unit at 145-lb pressure will be just saturated, also a curve showing saturation temperatures. Fig. 3 is predicated on a turbine blading efficiency of 76 per cent, and on an electric generating efficiency of 96 per cent. The power production corresponding to Fig. 1 is 381 kwhr per ton of pulp. Therefore, the excess kilowatt-hours above 381 shown in Fig. 3 may be credited to the high-pressure unit.

In other than very exceptional circumstances, the pressure required for generating all the by-product power necessary for operating the plant, will not exceed 700 lb gage which, it will be noted upon reference to Fig. 3, requires a corresponding temperature of 630 F.

Only a few years ago, a pressure of this magnitude was considered extreme. The past ten to twelve year period, however, has witnessed a very rapid development until today such steam conditions are considered commonplace, and the frontier has moved up to a pressure of approximately 1400 lb and a temperature of 900 F. In this development, construction methods have played a more important part in boiler construction than have materials. Ordinary carbon steel is still the accepted material for the boilers for the highest pressure. As a matter of interest, the tensile strength of steel is a maximum at a temperature considerably above the temperature of saturated steam at 1400 lb pressure. Carbon steel is also the accepted material for superheater construction up to near 800 F. Above this point special alloys are required for the high-temperature end.

In the development of high-pressure boilers, the drum construction has been the only item of the boiler itself which has presented any serious problem. So long as steam drums were constructed with riveted joints, a plate thickness of approximately $2^1/_2$ in. was about the limit. With a double butt strap, this made a rivet

length of over 7 in. and a rivet diameter of 2 in. To secure a satisfactory joint required extreme accuracy in the fit of butt straps, perfectly reamed holes, rivets machined to a micrometer fit, and a careful and thorough calking of plates and rivet heads.

The conservative pressure limit for which a boiler may be constructed depends to a great extent upon its general design. In the high-pressure field there are three general types in commercial use, namely, the box header straight tube boiler, the bent-tube multi-drum boiler and the sectional-header straight-tube boiler.

The limit of pressure of the box header type of boiler is reached first. To state a definite limit would no doubt lead to controversy, but certainly the popularity of this type falls off rapidly above 250 to 300 lb. It has, however, been built for pressures approaching 500 lb. The writer is not aware of the precise record limit. The flat, staid surfaces, and the throat construction between the box header and the steam drum, are constructions which are not well adapted to high pressure.

The limit of the bent-tube type of boiler is established by the strength of material which can be secured on a longitudinal line through a row of tube holes in the drum. As normally constructed, tubes $3^1/_4$ in. in diameter, spaced on an average of 6 in. centers, are used. This gives a solid metal distance between holes as drilled of slightly less than $2^3/_4$ in. The corresponding strength along a longitudinal line, therefore, becomes $2^3/_4$ divided by 6, or about 45 per cent of the solid plate. This has been increased in certain instances by spacing the tubes further apart, by using smaller tubes and by swaging the tube ends where they enter the drums. By the adoption of one or more of these means, boilers constructed for a pressure of 1400 lb have been built in a number of instances and are operating in an entirely satisfactory manner.

The pressure limit for sectional-header cross-drum boilers is least restricted. They have been successfully made for 1800-lb operation. There are so few tubes entering the drum in this design that they may be made to enter either through the double butt strap, or the tubes in a given longitudinal row may be staggered so that the distance between holes is twice or even three times what it would be without staggering. The drum thickness for a given pressure and drum diameter is therefore less in this design than for the bent-tube type. Assuming $2^1/_2$ in. plate thickness, the limit in pressure for bent-tube boilers with riveted drums is approximately 450 lb and for the sectional-header cross-drum type, approximately 750 lb. By making the drums below normal in diameter these pressures may be somewhat increased. This construction has, however, rapidly become obsolete.

In 1924 the Edison Electric Illuminating Company of Boston bought and installed the first super-pressure boiler. It was of the cross-drum sectional-header type, built for a pressure of 1200 lb per sq in. gage. To overcome the limitation imposed by riveted construction, the drum was made from a single ingot of steel forged into a drum complete with heads. It was not made in a boiler factory, but in a gun-making shop. The drum diameter was 48 in. inside and shell thickness $4^1/_4$ in. The overall length was 34 ft. The ingot from which this drum was made weighed 262,000 lb. The finished drum weighed 88,475 lb.

This drum was the forerunner of a great many similar drums. Perhaps the most outstanding production to date is the drums in a boiler for the Port Washington Station of the Milwaukee Railway Light and Power Company. These drums are 40 in. inside diameter by 62 ft long over the heads, and the shell thickness is $5^1/_4$ in.

Two grades of steel for forged drums are approved by the A.S.M.E. Power Boiler Code: Class 1 steel, having an ultimate tensile strength of 60,000 lb per sq in. and Class 2 steel, having a strength of 75,000 lb. Nearly all the forged drums have been made of Class 2 steel in order to keep the thickness to a minimum. This harder steel also makes better tube seats into which to roll tubes.

This type of drum construction has proved quite a satisfactory solution for large and very high-pressure boilers. It is too expensive a construction, however, for either small high-pressure boilers or for large moderate-pressure units. In the former case, the cost of forming the heads is such a large proportion of the total cost of

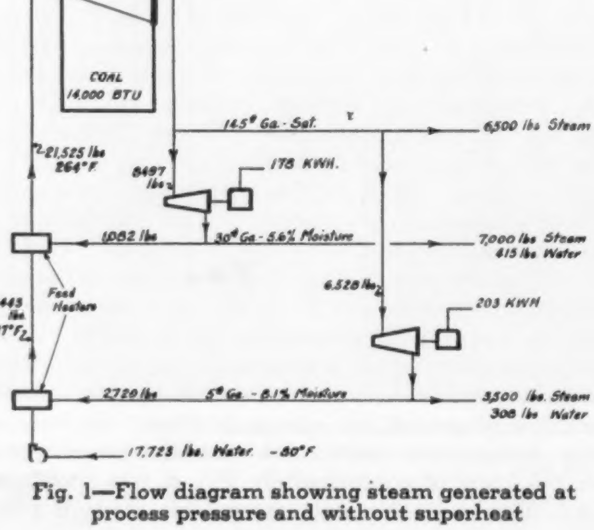


Fig. 1—Flow diagram showing steam generated at process pressure and without superheat

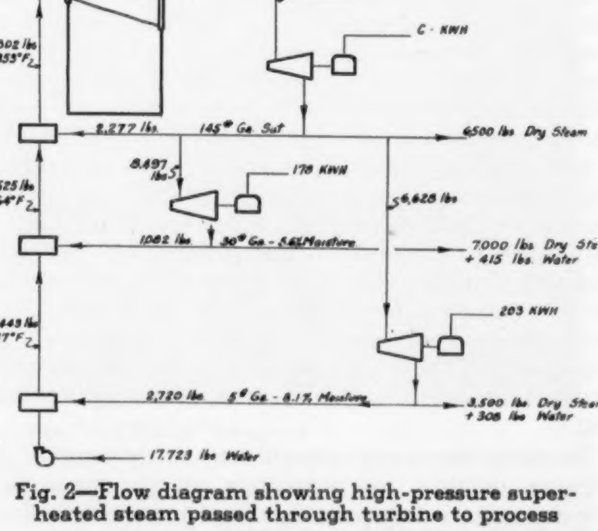


Fig. 2—Flow diagram showing high-pressure superheated steam passed through turbine to process

the drum that short drums become a very expensive article. In the latter case, the cost of making moderately thin drums was so high as to discourage their adoption.

With riveted drums at one end of the scale and forged drums at the other, a wide gap remained in the pressure range for which there was no suitable economic drum construction available. The obvious need stimulated the boiler companies in an effort to fill this gap, with the result that following a long program of research the A.S.M.E. Power Boiler Code formulated and adopted rules and regulations for the construction of electric fusion-welded drums. These rules and regulations became effective July 7, 1931. The steel specified in these rules had an ultimate tensile strength of 55,000 to 65,000 lb per sq in., design calculations being based on the lower figure. With further experiment and research, the technique of welding was developed for high carbon steel, and early in 1933 the A.S.M.E. Power Boiler Code approved the use of steel having a tensile strength of 70,000 lb per sq in. for welded construction.

Tests of the welds as made show consistently a strength equal to or better than the base metal, but as a precaution the rules specify that in design calculations the welds shall be assumed to be only 90 per cent. In addition to other requirements, the regulations require that all welded joints shall be X-rayed and that all completed drums shall be heat treated in an annealing furnace for the removal of all temperature strains produced in the process of welding. These two requirements, while recognized as being highly essential, add materially to the cost. The superiority of the construction, however, as compared with riveted joints, is so well recognized that the latter has become almost obsolete in the space of only two or three years.

There is no minimum limit in plate thickness required for boilers for which welded construction is applicable. Commercially, owing to the cost of X-raying and heat treating, riveted construction continues to be popular for plate thicknesses of approximately $^3/_4$ in. and less. The upper limit in thickness is influenced largely by the cost and practical difficulties encountered in forming the plates for welding. The fusion-welded drums for the most recent installation at the Connors Creek Station of the Detroit Edison Company are 4 in. thick. The design in this case was based on steel having an ultimate strength of 55,000 lb per sq in. The steam drum for a boiler recently placed in operation at Akron, Ohio, for the Firestone Rubber Company, is also 4 in. thick. It is designed for 1400 lb pressure, based on steel having an ultimate strength of 70,000 lb per sq in.

The A.S.M.E. Power Boiler Code just recently passed a ruling permitting the construction of boiler drums by the forging process, previously referred to, with separately formed heads welded on. This substantially reduces the cost of construction compared with forged drums with integral heads and brings such drums into competition with drums formed of plates with welded joints for plate thicknesses of around 4 in. and over.

With the foregoing construction approved, the increase in the cost of boilers with increase in pressure follows a reasonably smooth curve throughout the entire range. Small steps in the curve are due to successive increases in tube thickness from one gage to the next, but these are not important.

The superheat required in the paper industry is in no

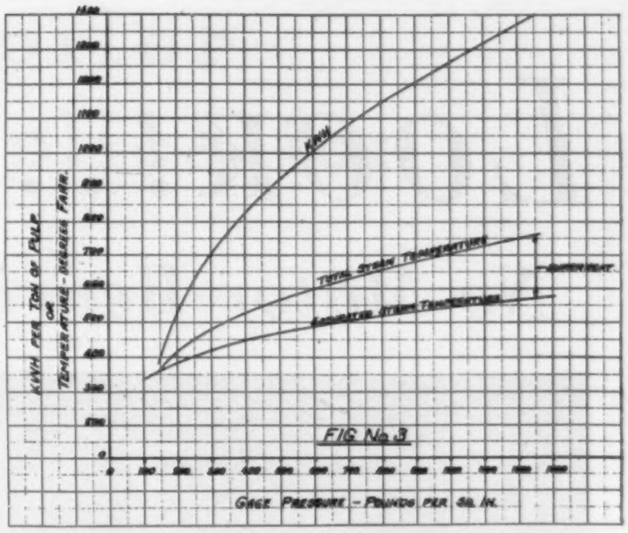


Fig. 3—Variation in power production with increasing pressure and total steam temperature required

case high enough to require special alloy steels. High pressure requires thicker tubes and headers. High pressure also requires high superheat (see Fig. 3) and a corresponding greater amount of surface. These two factors result in an appreciable increase in cost of superheaters with the increase in pressure, but no important construction or operating problems are encountered. Superheaters are in operation in this country for a temperature of 860 F with no operating trouble whatever. Units are now being built for 1400-lb pressure and 900 F. In both cases, alloy steel is required for the high temperature end. In addition, there is an experimental unit with separately fired superheater which is operating at 1000 F. From experience already gained, no difficulties of any character are anticipated with 900 F.

Boiler accessories, including blowoff valves, feedwater regulating valves, safety valves, water columns and gage glasses, have been developed in step with the increased pressure requirements. Of these only the gage glasses proved a knotty problem. It was found that the customary round gage glass was not suitable above a pressure of around 400 lb. At above this point it is advisable to substitute a flat gage glass mounted in a suitable steel frame such as has long been the practice in locomotive work. For the very high pressures it was found that the water attacked the glass so that it rapidly became opaque. To overcome this difficulty and also to prolong the life of the glass, a strip of mica is placed between the glass and the water, thereby excluding entirely any contact between glass and water.

Water conditions which have been found entirely satisfactory for 150 to 300-lb pressure may be found to be very troublesome indeed with operating pressure of 600 to 800-lb gage. No specific instructions concerning the treatment of feedwater fall within the scope of this paper. In the past several years the proper treatment of feedwater has become a highly specialized field and in no case should high-pressure operation be undertaken without consulting a specialist concerning the character of water available and the possibility of its being successfully treated for high-pressure operation. It should be added, however, that there are few situations which by suitable treatment cannot be handled in an entirely satisfactory manner.

The Benson Boiler and Its Application*

By FRANCIS HODGKINSON
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After reviewing new types of steam generators developed in Europe and experiences with the earlier installations of the Benson boiler, the author describes the principles of constant-temperature, variable-pressure operation in which the turbine load is met by regulating the boiler feed and the complicated governor mechanism of the turbine is eliminated. Performance of such a setup is analyzed and its economic application discussed.

THERE has been much activity in Europe during the last decade in the development of new forms of steam generators. Notably, these are:

The Benson "once-through" boiler, invented by Benson, an American, but developed by Siemens-Schuckert, of Siemensstadt, Berlin.

The LaMont boiler, an American invention, but it has excited more interest in Europe than in this country.

The Krupp "once-through" boiler, proposed by the Germania Werke at Kiel, Germany.

The Loeffler boiler, developed by the Vitkovice Mines Steel & Iron Works Corp. of Czechoslovakia.

The Sulzer "once-through" boiler, developed by Sulzer Bros. of Winterthur, Switzerland.

The Velox boiler developed by Brown, Boveri & Co., of Baden, Switzerland.

In this country, we have the experimental "once-through" boiler at Purdue University, and judging by a review of the U. S. Patent Gazette, much thought is being given to the subject.

Interest in this country has no doubt been stimulated by the thermal efficiency of the mercury-steam cycle on the part of the General Electric Company.

All of these boilers have been described in the technical press, so only certain of their characteristics will be referred to. The paper will confine itself to the characteristics and applications of the Benson boiler, a license for the sale and construction of which is enjoyed by the Westinghouse Electric & Mfg. Co.

The Krupp boiler is of the continuous tubular type without drums. Its chief characteristic is that about 10 per cent more feedwater is supplied than is evaporated. The 10 per cent water plus 90 per cent vapor are removed and separated in a separator. The water, containing salts and dust, is then drained to waste but its heat is conserved by a heat exchanger. The separated vapor is returned to the boiler wherein it is superheated. A feature is automatic regulating means to the end that the predetermined amount of excess feed is maintained. It is claimed the boiler may be operated with sea water for make-up feed in marine installations. I know of no case of this boiler having been reduced to practice.

The Loeffler boiler has attained considerable commercial success. I have seen several of them, notably those operating in the Trebovice plant (a really modern state-owned plant in Czechoslovakia) and there are no adverse comments to make. The I. G. Farbenindustrie A. G. installed a small experimental boiler which was subjected to trials with various kinds of feedwater containing impurities. The Farbenindustrie A-G Company concluded that it was more impervious to poor feedwater than any other type of boiler and therefore placed orders for three 100,000 lb per hr boilers. Contracts have been placed for a number of these boilers, including two of 300,000 lb per hr capacity each for Moscow.

One naturally looks askance at the steam pump of the Loeffler boiler. The pumps seem however to operate without difficulty and the gland problem appears to have been overcome. A limitation to this boiler, because of the energy required by the steam pump, is the operating pressure which seems to be standardized at 1910 lb per sq in. and a total temperature of 933 F.

The Sulzer boiler comprises a continuous single tube and operates with constant pressure. Feedwater is admitted at both the inlet of the tube and at a point intermediate of its length. Regulation of the steam temperature is accomplished by regulating the flow between the two inlets.

The Velox boiler is possibly the most startling of all these developments. It seems to be an outgrowth of an attempt to develop a successful gas turbine. The gas-turbine-driven compressor raises the pressure of air for combustion to about 22 lb per sq in. gage. The combustion chamber is lined with vertical tubes about 4 in.

* From a paper before the Engineers Society of Western Pennsylvania, Pittsburgh, Feb. 5, 1935.

in diameter, containing water. Each of these contains three small tubes about 1 in. diameter, through which flue gas passes at a velocity of 650 to 820 ft per sec, and it is in this portion that enormous heat transfer rates are secured. The radiant heat in the combustion chamber is effective on the one side of the large outer tubes lining the combustion chamber. The gases leave the combustion chamber at about 2250 F and are reduced to from 1380 to 1480 F in passing through the small inner tubes. These tubes are followed by diffusers, so that there is no particular loss of pressure. The gases then pass through the superheating elements on their way to the gas turbine which they enter at 840 to 930 F. The temperatures are reduced in the gas turbine to about 750 F and 2 lb per sq in. gage pressure, at which pressure and temperature they are forced through a feedwater economizer at 400 ft per sec and then to the atmosphere.

The heating surface surrounding the combustion chamber is completely filled with water, and ten to twenty times the weight of steam delivered is circulated through this surface. This mixture of water and a small quantity of steam is separated by a mechanism similar to a cyclone dust separator, by means of which the water is swirled, steam being given off from the center and led to the superheater, the water falling to a lower chamber in which sludge may collect and be blown down. The circulating pump draws its supply from a point above the chamber. It is stated that the saturated steam leaving the separator does not contain more than 2 per cent moisture.

This boiler would seem as impervious as any other to bad feedwater. It is stated that it may be operated with feedwater having 25 to 30 parts per million scale forming matter. Scale forming constituents will remain in solution because of the great ratio of water to steam being circulated, also because of the high water velocities.

The compressor is proportioned to give about 10 per cent excess air. Its speed varies with the quantity of gas and therefore with the output of the boiler. Coupled with the gas turbine is the compressor, and in addition, the water circulating pump, the fuel pump and a motor. The pressure drop through the gas turbine is proportioned so that it does not have quite sufficient energy for the duty, the difference being made up by the motor, which is used for starting and for automatic regulation. Upon a fall of steam pressure, for instance, automatic means in response to steam pressure speeds up the motor and the compressor, thus accelerating the change of air flow. The slight increase in speed increases the air quantity which in turn increases the energy to the gas turbine. The feed supply is automatically regulated in response to the head of water in the cyclone chamber and the fuel supply is made responsive to the air flow by means of a system of Venturi tubes. Heat transfer rates in the evaporating portion are of the order of ten times those obtained in ordinary practice, which results in reduction of space occupied.

The Benson Boiler

The original conception of the Benson boiler was to provide a continuous tube system having water forced into one end and superheated steam discharged from the other. It was believed that to be successful, it must operate at the critical pressure or higher, when there would be no ebullition in transition from water to steam. No heat of vaporization would be involved in the transition and the temperature of the fluid would be raised continuously. There would be no stage of heat absorption without any rise in temperature, as would obtain with sub-critical pressure. The density of the water would be equal to that of the steam. It was feared that without the precaution of operating the boiler at the critical pressure alternate slugs of water and steam would be driven through the tube system and operation would not be uniform.

Because of the thought that a "once-through" boiler must operate at critical pressure or higher, the earlier boilers were so operated and were provided with an expansion valve. The function of this was to back up the slightly superheated steam leaving the boiler, although superheated to the then regarded maximum safe temperature, to the critical pressure or higher, following which it was further superheated at some desired lower pressure. Naturally, at full flow, the desired pressure drop was arranged to take place in the superheating surface, the expansion valve being practically wide open at that time, and coming into service only at reduced flow.

The first Benson boiler, having a capacity of about 10,000 lb per hr was built by the English Electric Co., Rugby, Eng., in 1923. This boiler generated steam at the critical pressure, and the steam was expanded without work to 1400 lb per sq in. It was then superheated to 800 F.

Some trials were carried out at Rugby but shortly thereafter the patent rights were acquired by Siemens-Schuckert and the boiler was removed to Siemensstadt where further trials were undertaken. This boiler did little more than demonstrate the possibility of a "once-through" boiler generating steam at critical pressure.

Following this, two small boilers were built and installed, which served not much more than as a similar demonstration.

Between 1927 and 1930, the following boilers were built and installed:

	Lb per Hr
Technical High School at Charlottenburg (For research and instruction purposes)	6,600
No. 1 Cable Works boiler	66,000
No. 2 Cable Works boiler	100,000
Langerbrugge boiler	275,000
Hamburg-American Line Steamer "Uckermark"	44,000

All of these were originally constructed to generate at critical pressure and to expand the steam without work to some lower pressure at which it was employed in the prime mover. The steamer "Uckermark" and the Charlottenburg boilers were oil-fired; the others were fired with pulverized fuel.

The two Cable Works and the Langerbrugge boilers were arranged vertically and installed out of doors. Fuel was admitted at the top and descended through a central combustion chamber lined with heat absorbing surface. At the bottom was an ash hopper; the gases then ascended through passages outside the combustion chamber through the superheating elements, the reheater, if any, and an air preheater.

Serious difficulties were experienced with all these installations because of burning out of tubes exposed to radiant heat. With the earlier boilers, this was ascribed to ordinary carbon steel tubes not being sufficiently heat resistant. The later boilers were, however, equipped

with tubing of special alloy steel, but the difficulty persisted. When the tubes were examined after a burn-out, they were found to be clean, and it was assumed that scale formation within the tubes had not been a cause. In fact, a theory was advanced that because of operation at critical pressure and no boiling taking place, as ordinarily understood, no scale was deposited.

In getting a boiler of this type under way, it is customary first to circulate cold feedwater by means of the feed pumps, the water being bypassed to the condenser from the boiler outlet, and the bypassing being reduced as heat is received from the furnace until sufficient pressure and temperature for starting are obtained. Similarly, upon taking the boiler out of service, the bypass to the condenser is opened simultaneously with the closing of the throttle to the prime mover and with interrupting combustion. The feed pump is continued in operation until the boiler has cooled down. It is readily understandable that scale may have been deposited in the tubing at the transition point from water to steam, which interferred with the transfer of heat to a degree that the tubes exposed to furnace heat became burned.

This difficulty occurred with the "Uckermark" boiler on her first voyage. In Halifax, temporary baffles were installed in the furnace to reduce the heat received at that point. When the vessel returned to her home port, piping changes were made, which brought the construction to substantially present-day practice. Similar changes were then carried out on the other boilers.

As the boilers are at present arranged, the entering feedwater is first heated by gases before they leave the boiler proper if the feed is not adequately heated by extraction heaters. The feedwater is then led to radiant heat absorbing surfaces where further water heating is accomplished, but before the transition stage from water to steam is accomplished or evaporation completed, the fluid is led to contact surfaces where the gas temperature does not exceed about 1400 F, in which the transition stage is not only completed but some amount of superheating accomplished. Following this, the fluid passes contact heating surface exposed to high temperature gases or both contact heating surface and radiant heat absorbing surface, in which superheating is completed to the final temperature.

By these means, the final stages of evaporation are carried out where the temperature of the flue gases is low enough not to cause injury to the tubing with any reasonable degree of scaling. Obviously, however, the scale must be removed at intervals, the intervals depending upon the character of the feedwater. Generally it is sufficient to take the boiler out of service for a few minutes every 600 or 700 hr and circulate feedwater, when the deposited salts will go into solution. In special cases, where longer periods of continuous operation are required, it is proposed to provide outlets from the outlet end of individual tube packets, in which evaporation and some superheating are accomplished, together with means for flooding the packet. Salts may thus be disposed of with the boiler in operation. This method, however, has not been reduced to practice. The Langerbrugge boiler is said to be taken out of service once weekly. It has, however, operated continuously for a month without interruption on more than one occasion. The feedwater is said to contain 10 to 20 parts per million of scale forming matter.

Obviously, care must be exercised in the treatment and choice of feedwater. It should contain only soluble salts. Silicates should be avoided.

At Charlottenburg it was discovered that it is not necessary to operate a "once-through" boiler at the critical pressure. It may operate at any pressure, as low as 400 or 500 lb per sq in. From this there developed the principle of variable pressure, constant-temperature operation, in which feed, fuel and air for combustion are made responsive to load demand, the pressure being such as to sustain the load, there being, in theory, no control of steam flow between the steam generator and the turbine.

In 1930, a small test boiler was constructed solely for studying the problem of deposition of salts, measurements being made at various points along the fluid path. Experiments showed that the salt content in the delivered steam would go down with rising steam temperature and increase with falling temperature, in the latter case to an extent depending on the salt content of the original feedwater. This explained why burned out tubes had been found to be free from scale. Experiments with sub-critical pressures showed salt deposits occurred where the last fraction of water was evaporated. It seems to be shown that the salts in the delivered steam increase with pressure (density of fluid) and with the degree of concentration in the feed.

These developments naturally led to practically rebuilding the boilers. In the case of the Cable Works installation, the turbines were arranged to exhaust into heat exchangers which evaporated steam for the heating processes in the Works, thus maintaining uncontaminated condensate for use as feed for the Benson boilers which operate with a range of pressure between 2650 and 590 lb per sq in.

Constant-Temperature, Variable-Pressure Operation

With present day constant-pressure operation, it is customary to design large turbines with a number of nozzle groups operating on the initial stage, these nozzle groups becoming active one after another as load increases. The purpose is to obtain better efficiency at fractional loads by operating the active nozzle groups with higher pressures than if steam were throttled to a single group of nozzles. The nozzle groups are controlled by automatic valve gear and made responsive to the governor. The valves and gearing are costly and add to the complexity of the turbine. Beside these, frequently there are governor-controlled valves, for bypassing certain of the high-pressure turbine elements by means of which overloads may be sustained at some sacrifice of efficiency.

With the advent of the principle of variable-pressure, constant-temperature operation, all these costly and complicated valve mechanisms may be eliminated. The turbine has a single steam path. Theoretically, no valves whatsoever are required between the steam generator and the turbine. In practice, there must of course be an automatic throttle valve and a governor controlled valve, which normally will be wide enough open so that there is practically no pressure drop through the valve. The supply of fuel and air for combustion will be regulated in response to the speed of the prime mover. The function of the governor-controlled valve at the inlet to the turbine may be merely for safety to control the speed in the event of some untoward incident in operation.

Any excess steam at such a time may escape through safety valves.

It is understood that this type of boiler has small heat inertia. It contains comparatively little water when in operation, so its output may vary rapidly with changes in combustion rate. I have seen variations from full load to half load, back and forth, on the second Cable Works boiler (45 tons per hr), each change occupying less than two minutes.

However, it is not recommended that this type of installation would be applicable to a single machine operating on an isolated electric system with rapidly fluctuating loads, but it is eminently applicable to base load machines operating in conjunction with other machines, and in this respect, the general method of operation would be no different from that which obtains in large power stations.

With the constant-temperature, variable-pressure system of operation it is obvious that the curve of steam or heat consumption will be a smooth one from friction load to maximum.

For installations where high efficiency is sought, the maximum operating pressure selected will depend upon the capacity and speed of the turbine; that is, the pressure would be limited to that where the gain due to increasing pressure commences to be offset by diminishing efficiency of the high-pressure turbine elements because of the decreasing volume of steam. The greater the capacity at a given turbine speed, the greater the pressure that may be justified.

The physical properties of steam fortuitously lend themselves to the constant-temperature, variable-pressure system of operation. With the variations of vacuum that naturally exist with varying quantities of steam to be condensed, the heat drop at any load is nearly constant. This is illustrated by the Mollier diagram. Similarly, inasmuch as volume varies in inverse proportion to pressure, the volume of steam throughout the turbine remains nearly constant except for the last few rows of blades, so that a steam path proportioned for one load is nearly correct for another, and the efficiency of the turbine alone, excluding mechanical losses, remains substantially constant, regardless of load.

Efficiencies Indicated by Example

Assume an installation operating with 2500 lb per sq in. abs 850 F at the maximum continuous load, and that the condenser is designed for 28.5 in. vacuum at full flow, with corresponding higher vacuum at reduced flow. There is one stage of reheating which reheats the partially expanded steam to 850 F. A 5 per cent pressure drop through the reheater has been allowed. Also, the internal turbine efficiencies which have been assumed average 81 per cent for the steam path before reheating and 87 per cent after reheating, which may easily be realized in machine of appropriate capacity.

Under such conditions, assuming 5 per cent pressure drop from within the turbine into the heaters and that the heating steam by the time it reaches saturation in the heaters has raised the feedwater to within 10 F of the saturated steam temperatures, the heat in the superheat raising the feed temperature the equivalent amount higher in falling to saturation, the plant would have the following characteristics:

	100 Per Cent Flow	50 Per Cent Flow
Initial steam pressure, lb sq in.	2500	1250
Initial steam temperature, F	850	850
Pressure entering reheater	325	162.5
Quality of steam entering reheater	1.3 per cent moisture	58 F sup.
Reheat temperature	850	850
Exhaust pressure	0.074	0.044
Quality exhaust steam, per cent moisture	8.7	6.9
Temperature of steam leaving final heater	595	476
Per cent weight of initial steam entering condenser	52.8	62.6
Btu/kwhr of internal energy	7780	7960
Thermal efficiency of internal energy	0.438	0.429
Btu/kwhr of generator output excluding auxiliaries (4 per cent constant mechanical and electrical losses)	8100	8480
Thermal efficiency, ditto	0.420	0.402
Btu/kwhr of generator output with deduction for feed pumps and heater condensate pumps at 50 per cent efficiency circulating pumps and air ejector but excluding losses incidental to combustion	8570	8780
Thermal efficiency, ditto	0.398	0.389

Such efficiencies as these would hardly seem reliable by any other practicable cycle. This one is evidently eminently practicable. If 85.5 per cent boiler efficiency, including fans, etc., is allowed, the test power station rate at full load would be 10,000 Btu/kwhr, or 34.1 per cent thermal efficiency.

The greater apparent falling off of efficiency at fractional load of the feed heating example, as compared with one without feed heating is because of the lower temperature of feedwater at the lower load and the lesser quantity of steam extracted.

The essential engine room auxiliaries work out at 5.6 per cent of the generator output at full flow. The feed pump is of course an important item. Its work at 50 per cent efficiency is 2.8 per cent of the generator output at full flow.

The fact that only 52 per cent of the weight of the initial steam at full flow reaches the condenser, i.e., the total weight of high-pressure steam is nearly twice that of the exhaust, the difference being condensed in feedwater heaters, simplifies the turbine designer's problem. It enables him, on the one hand, to devise high-pressure elements that are efficient with what would otherwise be the small volume involved and, on the other hand, to provide blade area enough for the enormous specific volumes at exhaust pressure.

This feature further permits the units being built in smaller capacities than would otherwise be practicable. In any event, such machines could not be built in capacities much less than 30,000 or 40,000 kw at 3600 rpm.

The foregoing presupposes a Benson boiler operating with a complete condensing turbine combination with feed heating arranged as described. Probably the most common application in the immediate future will be superimposing a Benson plant over an existing plant when the capacity may be increased some 50 per cent and the efficiency some 30 per cent depending upon the characteristics of the existing plant. The most desirable method of accomplishing this is by, as it were, marrying the high-pressure turbine element to certain of the existing low-pressure elements, when the receiver pressure between the two systems would also be variable, and with equal quality of low-pressure elements and arrangement of feed-heating, the performance would be the same as in the foregoing. The control might be by making combustion and feed responsive to load demand, the low-pressure elements operating with open valves,

generating energy according to the quantity of steam supplied to them.

There will, however, be many instances of superimposing high-pressure elements where it is desired to maintain some of the low-pressure boilers in operation and arrange for the exhaust from the high-pressure turbines to be joined to the live steam header serving the low-pressure turbines. In this case, while the Benson boiler may operate with variable pressure, the receiver pressure must be constant. Regulation may be accomplished by means of the governors of the low-pressure turbines and the heat storage of the low-pressure boilers made use of; that is, the low-pressure plant would be operated as usual, the high-pressure boiler fired and fed at a rate to give the desired output, unforeseen and minor variations of load being taken by the low-pressure system. With this kind of a system, no automatic regulation of the high-pressure boiler is necessarily required. A push button control would serve, or at most, combustion made automatically responsive to steam temperature, the feed pump being set to that corresponding to the desired load.

It should be pointed out that with this kind of an installation, i.e., the high-pressure elements operating with variable initial and constant back pressure of the order of 300 lb per sq in., while the performance may be ideal at full flow, difficulties may occur at fractional flow because the high-pressure exhaust temperature will rise as the flow decreases. This renders difficult the control of the reheater. In fact, with extremes of light load, desuperheating might be required. This difficulty may be, in part at least, overcome by operating the high-pressure plant at constant initial pressure like any ordinary plant, and if the turbine is provided with group nozzle control, better performance would be obtained at the points of load where full pressure exists at the respective nozzle groups.

Alternatively, a simple system would be to arrange that the initial temperature decrease as flow decreases, i.e., the temperature reducing as pressure reduces. This would seem to introduce no particular problem of control either of the initial steam or the reheat. This entails, however, some falling off of efficiency at fractional flows, which would be inconsequential if the high-pressure part of the plant is operated most of the time at full flow.

The principle of variable-pressure operation lends itself also to a plant designed for a certain base load, but capable of sustaining enormous loads during brief peak periods; the peak load sustained merely by increasing pressure. In such a case, the condenser may be proportioned for the base load, so there would be a substantial reduction of vacuum during the peak. The generator may be of less capacity than that corresponding to the peak load according to the duration of the peak.

Regulation

The method of regulation which will be recommended is not altogether determined. Presumably, the system will vary according to the individual installation. For superimposed plants operating with constant back pressure, no automatic means of regulation seems imperative. The Cable Works and Langerbrugge installations are operated entirely by push buttons located on a panel with pressure and draft gages, temperature and CO_2 indicators, etc. As stated, the automatic control of combustion in response to steam temperature is at most all that is required with perhaps a means of interrupting combustion in case of failure of the feed pump. Of course, the turbine must be protected by governors for safety, which would only come into operation under some untoward circumstance, when safety valves would be depended upon. In the case of steam from the Benson boiler expanding through turbine elements to condenser pressure that are independent of the rest of the plant, automatic regulating means become desirable.

One automatic means is to provide the turbine with the usual governor controlling a single valve admitting steam. Under constant load, the setting would be such that a predetermined moderate pressure drop would obtain over this valve, which is employed to give the impulses for regulation. On an increase in load the pressure drop over the valve lowers and fuel and feed are increased. The lowering of the pressure drop enables the turbine to sustain the increased load, at least momentarily, because of the disappearance of the pressure drop. On a decrease in load, the reverse occurs as far as combustion and feed control are concerned, but in this case the load is instantaneously controlled because there is no limit to the increase in pressure drop. With a sudden and great decrease in load, the safety valves on the boiler might blow, although ordinarily they would be set some hundreds of pounds higher than the maximum working pressure.

Another method, not without attractiveness, is for the usual turbine governor to control the speed of the feed pump and make combustion responsive to both feed flow and steam temperature. This has the advantage that in case of failure of the feed, combustion would be interrupted.

Obviously, at this time there is little accurate knowledge of costs. The importance of reducing capital charges as compared with improvements in efficiency is fully recognized. While the turbine will have more elements, because of the high pressure and greater heat drop to be dealt with, etc., the cost may be reduced because of the absence of valve gear for nozzle grouping, by-passing, etc. The greater cost, because of more elaborate feedwater heating is in part offset by the smaller condenser. The feed pumps and heater condensate pumps will be more costly than present day practice.

As concerns the boiler, with equal gas velocities the heating surface will not differ greatly from present day practice. While the heat transfer rate will be slightly increased by reason of higher fluid velocities within the heating surface the heating surface per unit weight will be increased because the tubes are smaller than in usual practice for equivalent pressures. The material of the tubes throughout will be the equivalent of what must be used in superheater tubes for equivalent temperatures, which will add to the cost. This, however, is more than offset by the absence of drums.

Short Course in Coal Utilization

The College of Engineering of the University of Illinois, through its Department of Mining and Metallurgical Engineering and Department of Mechanical Engineering, will offer another short course in Coal Utilization at Urbana on June 11, 12, and 13, 1935. The registration at last summer's short course was 146, and included men from distant states.

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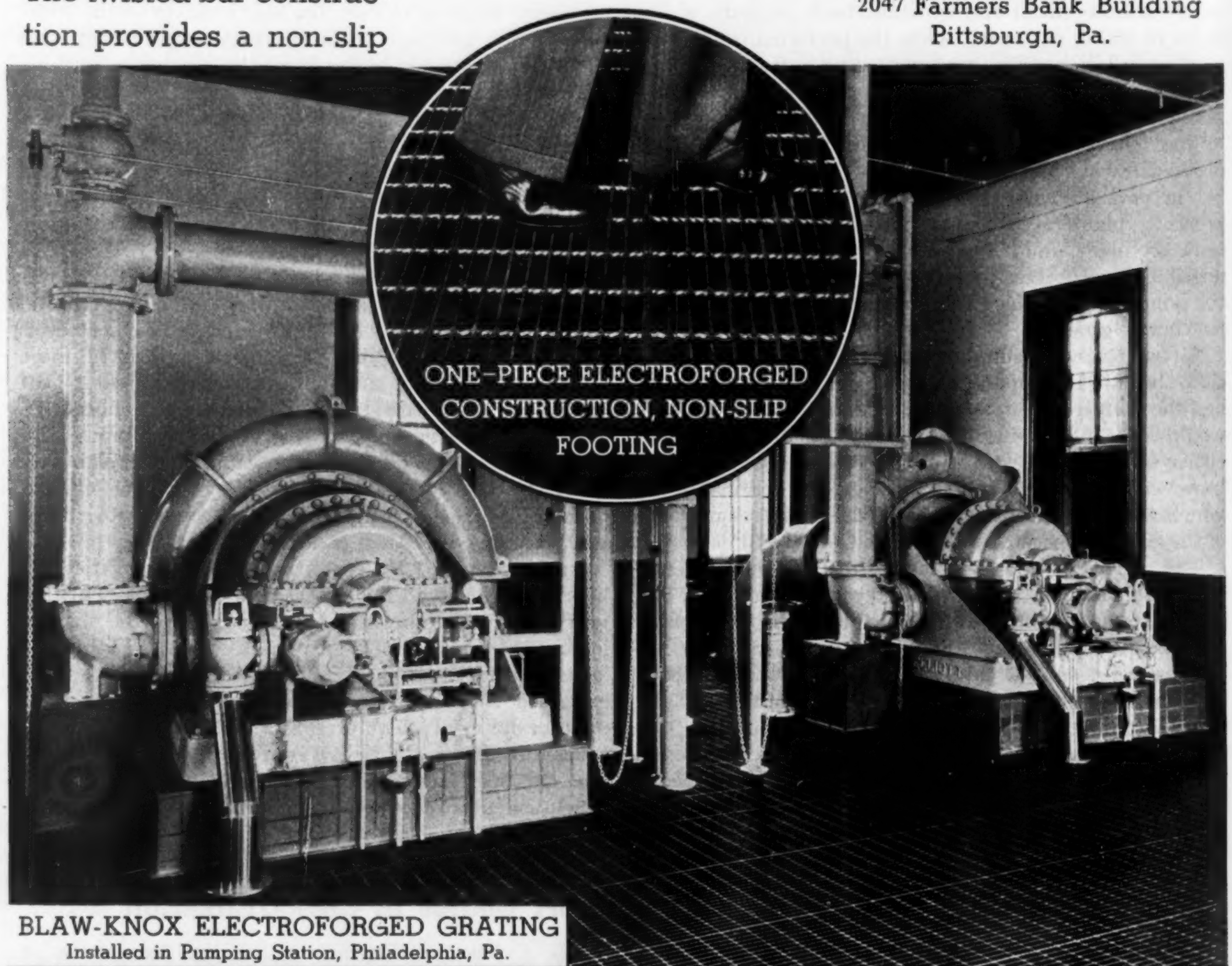

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Heat Content of Stack Gases

KENNETH A. KOBE

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An early number of COMBUSTION[1] contained a table and chart from which the specific heat of stack gas from various fuels could be found. This chart had the disadvantage of being derived for a certain fuel of fixed analysis fired with 50 per cent excess air. This lacks the flexibility of the method based on the total heat content of a mol[2] of the various constituents of the gas. The pound-mol as a basis for combustion calculations has increased in use as it allows a more general application.[3,4]

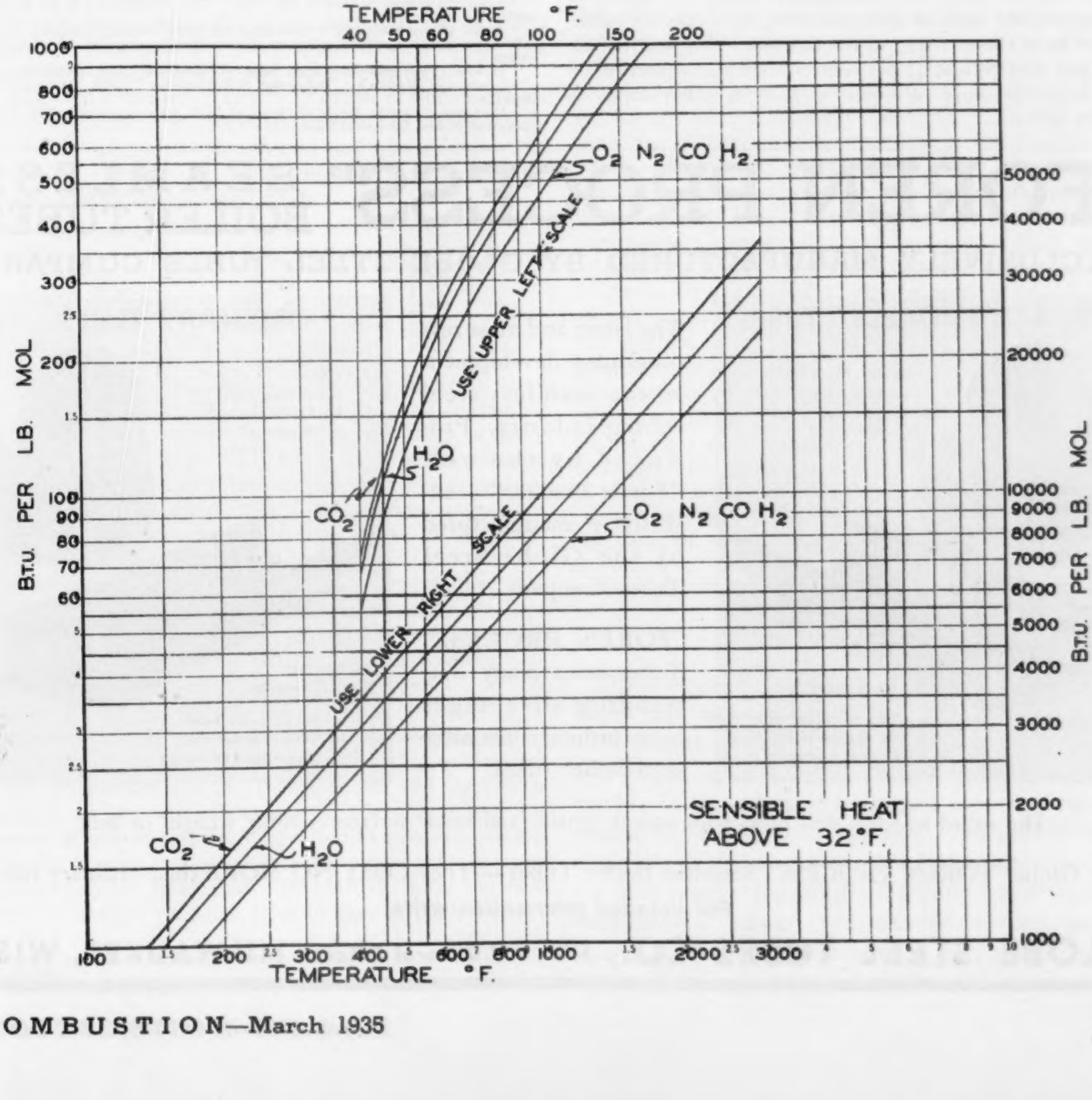
The accompanying chart shows the sensible (or total) heat content of various gases above 32 F in Btu per pound-mol of the gas. These curves are the integrated specific heat equations given by Eastman.[5]

The following calculations shows the weight in pounds contained in a pound-mol of gas.

Gas	Molecular Weight	Gas	Molecular Weight
CO_2	44	H_2	2
CO	28	H_2O	18
O_2	32	SO_2	64
N_2	28	CH_4	16
air	29		

Thus, there are 32 lb of oxygen in a pound-mol; for air, an average of the various constituents gives 29 lb of air in a pound-mol.

A problem may be solved showing the application of the method. The ultimate analysis of the coal is known to be carbon 78.4 per cent, hydrogen 5.6 per cent, oxygen 8.3 per cent, nitrogen 1.1 per cent, sulphur 1.0 per cent and ash 5.7 per cent. This ultimate analysis of the coal



may be obtained from the mine or an approximate value from various Bureau of Mines bulletins showing the analyses from various mines in the district in which the coal was mined. The flue gas analysis gives the volume per cent of the components on a dry basis, and volume per cent and mol per cent are numerically equal. The flue gas analyzes, carbon dioxide 14.0 per cent, carbon monoxide 0.4 per cent, oxygen 5.5 per cent and nitrogen 80.1 per cent. Select as the basis for the calculations 100 mols of the flue gas analyzed. Basis: 100 mols flue gas

Comp.	Mols	Mols C
CO_2	14.0	14.0
O_2	5.5	
CO	0.4	0.4
N_2	80.1	
	100.0	14.4

From the mols carbon in the flue gas, the water formed in the combustion of the coal may be calculated. All hydrogen in the coal forms water. The molecular or atomic weight of carbon is 12.

$$\frac{14.4 \times 12}{0.784} = 220.4 \text{ lb coal fired per 100 mols of flue gas}$$

$$\frac{221 \times 0.056}{2} = 6.2 \text{ mols of hydrogen in the coal; also}$$

mols of water formed on combustion.

If the air used for combustion carries considerable moisture, the mols of water entering here may be calculated from the nitrogen in the flue gas. Suppose the air (79 per cent N_2 and 21 per cent O_2) has a dew point of 50 F (vapor pressure of water = 0.36 in.), barometer is 29.92 in.

$$29.92 - 0.36 = 29.56 \text{ in. partial pressure of air}$$

$$\frac{80.1 \times 100 \times 0.36}{79 \times 29.56} = 1.2 \text{ mols of water from the air}$$

$$6.2 + 1.2 = 7.4 \text{ mols of water accompany 100 mols of flue gas}$$

Thus for every 100 mols of flue gas (dry) 107.4 mols of stack gas (wet flue gas) leave the furnace.

If the coal and air enter the furnace at 80 F, and the stack gas leaves at 600 F the heat carried out in the stack gas may be calculated from the chart. As CO, O_2 and N_2 are on the same curve, these may be added together. Basis: 100 mols flue gas (= 107.4 mols of stack gas)

Comp.	Mols	Heat Content Per Mol 600 F	80 F	Dif.	Total
CO_2	14.0	5600 −	440 =	5160	72,200
CO, O_2, N_2	86	3900 −	330 =	3570	307,000
H_2O	7.4	4850 −	400 =	4450	32,900
	107.4				412,100

Thus 412,100 Btu are lost with every 100 mols of flue gas. It was previously found that 221 lb of coal produced 100 mols of flue gas, so that $\frac{412,100}{221} = 1,865$ Btu are lost per pound of coal fired.

It is believed that the use of the chemical unit, the mol, saves a great deal of time in calculation where accurate results are desired.

[1] Anon., "The Specific Heat of Flue Gas." COMBUSTION, vol. 3, No. 4, p. 44 (1931).

[2] A mol of any substance is that quantity whose weight, expressed in any convenient unit as pounds or grams, is numerically equal to its molecular weight.

[3] Dawson, "The Mol Saves your Time." *Power*, vol. 76. p. 293 (1932).

[4] Lewis and Radasch, "Industrial Stoichiometry," 1926, McGraw-Hill Book Co.

[5] Eastman, "Specific Heats of Gases at High Temperatures," 1929, U. S. Bureau of Mines, Technical Paper 445.

Treating Coal for Sulphur Correction*

By L. P. Crecelius†

The advance in the art of power production has been signalized by much higher rates of burning coal with an accompanying diminution of air supplied. The effect has been to bring about much higher furnace temperatures than formerly and to decrease materially the amount of air available for oxidizing the various elements in the coal. Furthermore, it has operated to increase the speed of heat liberation, and therefore, decrease the time element for combustion.

This change is disqualifying and eliminating, to a considerable degree, the use of coals high in iron sulphur compounds, because of the objectionable clinkering when such coals break down, fusing to the iron of the grate surfaces. At heavy overloads, particles of coal are driven off from the burning fuel and are blasted against the boiler surfaces. Owing to the high temperature of the furnaces, much in excess of 2140 F, the melting point of ferrous sulphide, these particles are more or less plastic and give rise to tube slagging. Also, the ferrous sulphide particles collect on the economizer and preheater surfaces, where, due to a relatively lower temperature, the ferrous sulphide oxidizes to ferric sulphate, which in turn converts the sulphur dioxide of the flue gases into sulphuric acid and causes corrosion.

Coal ash is composed largely of oxides of silicon, aluminum, calcium, iron, small quantities of magnesium, titanium, phosphorous, sodium and potassium. The chemical composition varies widely, but in general comes within the following limits:

Constituents		Per cent
Silica	(SiO_2)	20.000–60.000
Alumina	(Al_2O_3)	10.000–40.000
Ferric Oxide	(Fe_2O_3)	3.000–43.000
Calcium Oxide	(CaO)	1.500–18.000
Magnesium Oxide	(MgO)	0.500– 4.000
Titanium	($Ti\ O_2$)	0.003– 3.000
Phosphoric anhydride	($F_2\ O_5$)	0.003– 0.800
Alkali	(Na_2O & K_2O)	1.000– 5.000

Coal high in iron, lime and alkali, is likely to have an ash which is readily fusible, whereas coal containing relatively large amounts of alumina and silica is likely to have a fairly refractory ash. Mixtures of alumina and silica, while very refractory, become less refractory with the addition of iron oxide, calcium oxide, magnesium oxide, sodium oxide and potassium oxide, all of which operate to reduce their fusing temperature.

Sulphur usually occurs in coal in three forms: (1) sulphur combined with iron as pyrite, or markasite, and known as iron pyrites (FeS_2); (2) sulphur combined with the coal as organic sulphur (S); and (3) small amounts of sulphur in the form of calcium sulphate ($CaSO_4$), or iron sulphate ($FeSO_4$) and water.

Sporadic efforts have been made to remove the pyritic sulphur from the coal. Two methods that have received some prominence are the Trent process and the Smith process. There are others, but in the main these are modifications of the Trent and Smith processes which stand as the two fundamental means employed to remove pyritic sulphur from coal. In both of these the coal must be ground very fine so as to pass through a forty-mesh sieve in order to expose the impurities sufficiently so that they may be removed. By the Trent process the removal is done by depositing the powdered fuel into a container holding an emulsion of oil and water which is kept agitated. In this emulsion the pure coal collects into balls which float on the surface; whereas the impurities fall through to the bottom where they may be removed. The Smith process also contemplates the grinding of the coal into a very small size in order to expose the pyritic sulphur which usually extends through the entire coal structure. This powder is let fall between powerful electro-magnets which withdraw the pyritic sulphur, allowing only the coal to pass by. In both cases, therefore, the coal structure must be destroyed in order to expose the impurities, and likewise the finished product must be again restored to size by means of briquetting, or otherwise, and on the whole the cost of so treating the coal is excessive, on the order of $3.00 or $4.00 per ton. It is because of the expense involved that these methods are not generally employed.

More recently a method of chloridizing coal to decompose the pyritic sulphur while the coal is burning is coming into more general use, having the advantage of being much less costly. This is based upon the fact that when coal high in iron-sulphur compounds is burned in the presence of a moderate amount of chlorine, much of the difficulty resulting from the iron-sulphur compounds is overcome, under the operating conditions enumerated.

The decomposition of the ferrous sulphide particle leaves the flue dust comparatively free of sulphides and sulphates and thus eliminates corrosion. Again, it has been found that the decomposition of the ferrous sulphide particle, reduces the adhesive nature of the fly ash to collect and accumulate upon boiler tube surfaces, with the result that coals, even though they be high in iron sulphur compounds, may be used at high rating without the formation of excessive tube slag.

Iron to be available for slagging must be in the form of iron oxide, either as (FeO), or as (Fe_2O_3). Silica will not combine with iron when the iron is in the form of ferrous sulphide (FeS). By means of the decomposition of the ferrous sulphide particle of the coal ash, thus more or less freeing the iron of sulphur, it is taken into solution by the silica and lime of the coal ash to form a neutral ferr-calcic-silicate slag. Such a clinker does not adhere to the grate surfaces and is more or less friable and easily removed by any of the conventional dumping devices employed on modern stokers.

* From a paper at the recent fuels conference held at the University of Wisconsin.

† President, The Coal Processing Co., Cleveland, Ohio.

The average daily production of electricity for public use in the United States in January, according to the U. S. Geological Survey, was 266,700,000 kwhr, an increase of about 2.5 per cent from the average daily production in December. The normal increase from December to January is 0.5 per cent. The production of electricity in 1935 therefore started off 8 per cent above the daily rate for January 1934, slightly longer than the daily rate for January 1929 and 4.5 per cent smaller than that for 1930 which was the maximum recorded rate for January.

New Laws Applied to Power Contracts

In the light of present codes certain aspects of the anti-trust laws have been superceded. How this affects the law of contracts as applied to power agreements, as indicated by some recent court decisions, is discussed by the author.

By LEO T. PARKER,
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PROBABLY one of the most important changes of the old law, arising from codes and resultant conditions, involves anti-trust laws.

Under ordinary circumstances of the past any person or official of a corporation, who agreed with a competitor as to prices to be charged on a power contract, was considered a violator of the law. This is true because such laws as the Sherman and Clayton Anti-Trust Laws were enacted especially for the purpose of preventing and eliminating price fixing, combines and monopolies.

The Sherman Anti-Trust Act was enacted in 1890 and several years later the Clayton Act importantly modified the Sherman law. Section 1 of the Sherman Anti-Trust Act provides in part that "every contract, combination in the form of trust or otherwise, or conspiracy in restraint of trade or commerce, among the several states or with foreign nations, is hereby declared to be illegal." Section 2 of this law provides that "every person who shall monopolize, or attempt to monopolize, any part of the trade or commerce among the several states, or with foreign nations, shall be guilty of a misdemeanor."

The Clayton Act provides that it is unlawful for any person to enter into a contract for goods, wares, merchandise, machinery, supplies or other commodities, whether patented or unpatented, if any provision of the contract may be interpreted to mean that either of the contracting parties agree to substantially lessen competition or intend to create a monopoly in any line of commerce.

New Laws Effective

Obviously, any combine or contract by which manufacturers agree to perform certain acts which tend to eliminate competition and uphold the price for a commodity has been held to be illegal. However, it is well known that the Sherman and Clayton Laws were enacted when business conditions generally were considered good and on continuous improvement and expanse. Subsequently certain governmental emergency laws and regulations have been enacted and codes of working, manufacturing and selling have been put into operation. Obviously, since the general enforcement of such codes and regulations violate the Sherman and Clayton Anti-Trust Laws a great part of the old law relating to contracts recently has been changed or importantly varied.

Essentials of Present Contract Law

Our higher courts have consistently held that a valid and legal power contract is an agreement between two or more parties by which each party is *expressly or impliedly* obligated to do something, not prohibited by law, within a specified time. It is not necessary that the ordinary contract be in writing, and it may be either expressed or implied. An expressed contract is one where the terms of the agreement are stated in so many words, and an implied contract is one of which the law *presumes* a promise of one of the contracting parties to perform a service for the other.

A voidable contract is one in which only *one* of the parties may decide whether the contract shall be void or enforceable. The most common kinds of voidable contracts are those having present the elements of fraud, undue influence, misrepresentation or mistake. Another form of voidable contract is where an employee makes a contract for an employer without any authority.

A void contract differs from a voidable contract in that the former creates *no* legal obligations and, therefore, cannot be made into a valid agreement by either party. Void contracts are those that are prohibited by clauses in the United States or State Constitutions, prohibited by valid statutes, or otherwise illegal, as against public policy and detrimental to the general public.

Requirements of Valid Contract

It is generally held by the higher courts that a power contract is valid, (1) if one contracting party submitted an offer which the other unconditionally accepted; (2) if the obligations of both contracting parties are definitely fixed; (3) if the object of the contract is legal; (4) if both parties are sane and of legal age; (5) if the duration of the contract is clearly specified; (6) if the quantity and quality of material or work is clearly indicated; (7) if the parties are mutually obligated to perform one or more acts; and (8) if the contract is not in violation of a state or city law.

Therefore, a contract is void and unenforceable by which one of the parties merely *promises* to perform a service or obligation, if the other party is not obligated to perform some act, service or duty. This is true because a mere promise by one party, without a definite obligation being assumed by the other party, is not a mutual obligation.

Offer and Acceptance

The courts have established the law that neither party to a power contract is bound by its terms, unless it is shown conclusively that one party submitted a definite

offer which the other party *unconditionally* accepted. In other words, a valid contract is not completed where one party makes an offer and the other party either fails to accept the offer, or accepts it conditionally.

On the other hand, it is important to know that any *authorized* employee may submit a valid proposal or accept an offer. If either the offer or acceptance is made by an employee of a private firm, it is valid and binding provided prior acts or promises of the employer induced the other party to believe that the employee was properly authorized to transact the business.

However, if the business is incorporated, the law is different. The manager of a department usually is a legal representative of the corporation and he may accept or make valid offers, providing the contract form contains no stipulation to the contrary. If, however, the other party to an agreement is notified in any manner that only officers of the corporation may make valid contracts, then department managers cannot legally make or accept an offer. This law was upheld in Ralston V. Arthur, 139 S. W. 366.

The facts of this case are that a representative of a corporation made a written contract which contained a provision that the contract would not be valid until it was accepted and acknowledged in writing by an officer of the corporation. The sales manager of the corporation acknowledged and accepted the contract. Later litigation arose over validity of the contract and it is interesting to observe that the higher court held that a binding contract was not completed, since the sales manager was not an officer of the corporation.

Breach of Contract

It is well settled law that both the contracting parties are bound to fulfill the *precise* terms of the agreement. In other words, the instant one party fails to fulfill the assumed obligations he performs a legal breach for which he is liable in damages. This rule of the law is applicable whether the contract consists of a signed order, or an agreement made by mail, or any other valid sales agreement. Moreover, after the contract is made any act of either party, which interferes with fulfillment of the obligations of the agreement by the other party, is a breach.

After one of the contracting parties has performed an act, which results in a legal breach of the contract, the other party is privileged to rescind the contract and he has choice of doing either of these three things: (1) He may refuse to perform his obligations of the contract and sue the other party for damages and profits equal to his financial loss resulting from the breach; (2) or, he may immediately file suit and compel the other party to fulfill the exact terms of the agreement; (3) or, the parties may compromise the breach and make a new contract.

James W. Parker, for some years past chief engineer and assistant general manager of the Detroit Edison Company was elected a vice president of that company at the recent annual meeting of the Board of Directors. Mr. Parker is well known in utility circles and has long been active in A.S.M.E. affairs. Following graduation from Cornell University in 1908 he entered the operating field, first with the De Kalb Power & Light Company, then with the Vicennes (Ind.) Street Railway Company and later coming to the Detroit Edison Company as boiler room engineer, ultimately advancing to the position of chief engineer.

Walter F. Wells, senior vice president and general manager of the Brooklyn Edison Company retired on March first after forty-two years with that company and its affiliates. Throughout his career Mr. Wells had been active in the technical and general activities of the electric light and power companies and had served as president of both the Association of Edison Illuminating Companies and the National Electric Light Association.

George C. Estill was recently elected president and general manager of the Florida Power & Light Co.

W. E. Bird, executive vice president of the Hartford Electric Light Company since 1929, was recently elected president of that company, succeeding Samuel Ferguson who becomes chairman of the board of directors.

W. S. Elliott, president of the Elliott Company, Pittsburgh, died on February 21 from a heart attack. He was born in Wellsville, O. in 1863 and was graduated from Cornell University with the degree of mechanical engineer. He had been president of the Elliott Company for the past thirty years.

STEAM ENGINEERING ABROAD

As reported in the foreign technical press

Boiler Obsolescence in Germany

The results of an interesting survey covering the age of stationary boilers in Prussia are given in the January 1935 issue of *Wärmewirtschaft und Dampfkesselwesen* (Berlin). This survey covered 8935 boilers of various types, representing over 54 million square feet of heating surface. Of these 17.1 per cent are water-tube boilers, representing over 50 per cent of the total installed heating surface; 56.1 per cent are fire-tube boilers accounting for 39.8 per cent of the total heating surface; and 16.8 per cent of the number, or 7 per cent of the heating surface, is in waste-heat boilers. The remainder is made up of special types of boilers.

As might be expected the average age of the water-tube boilers is less than those of the fire-tube type. Of the former, 24.3 per cent have an age of 10 yr or less, 65.5 per cent are under 20 yr and 8.2 per cent are over 30 yr old. Only 5 per cent of the fire-tube boilers come within the 10-yr class, 19 per cent within the 20-yr class and 59.5 per cent within 30 yr. A few are still in service after 65 yr. For the waste-heat boilers 18.1 per cent are under 10 yr, 42.5 per cent under 20 yr and 72.4 per cent under 30 yr, which means that 17.6 per cent of this type are still in operation after 30 yr.

Considering boilers of all types, 16 per cent are not over 10 yr old, 44.5 per cent are not over 20 yr old and about 23 per cent are over 30 yr old.

A New Colloidal Fuel Process

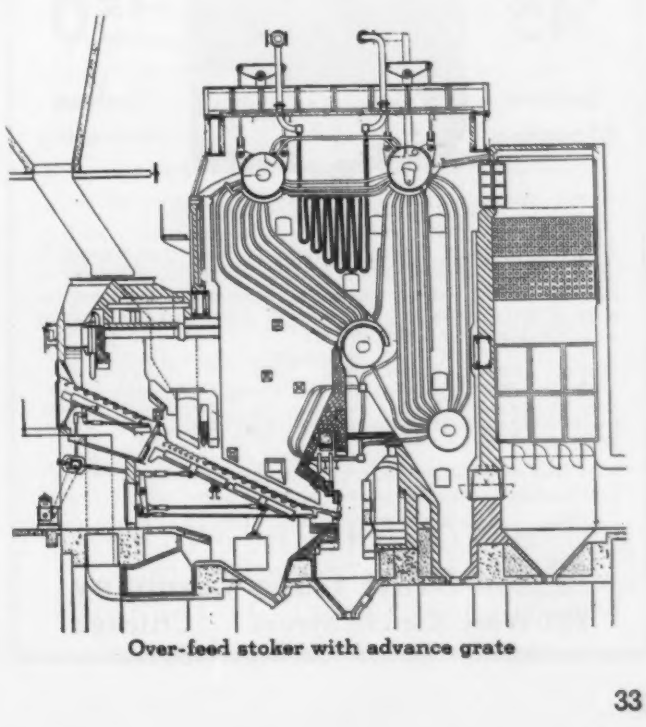
For some years past considerable experimental work on colloidal fuel has been going on in Great Britain. In order to provide stability to the mixture, fixatives, such as lime-rosin, have been employed. It was found, however, that the fixatives invariably formed a gelatinous coating on the walls of the storage compartments and that sometimes the coal tended to separate from the oil during its passage around bends and through valves.

Considerable interest therefore attaches to a process devised by S. L. Wyndham and described in *Engineering* of Feb. 1, 1935. Approximately equal quantities of fuel oil and washed duff, capable of passing through a $^1/_8$-in. mesh and dried to not more than 4 per cent moisture, are mixed without preliminary grinding and without any stabilizer. The coal from a hopper is fed by a worm to an inclined cylindrical mixing chamber, provided with a helix on its inner surface and rotating on roller bearings. The oil is sprayed into the mixing chamber just below the worm which feeds the coal. The combined action of rotation and the helix thoroughly mixes the coal and oil and the mixture is discharged at the lower end into the first of a series of mills. This has rolls 0.008 in. apart and is provided with a comb. From this mill the mixture is pumped to the second mill which has its rollers placed 0.004 in. apart, one of which runs three times as fast as the other. Here the mixture is reduced to such a size that practically all will pass through a 60-mesh screen. Increased fineness, up to 99 per cent through a 200 mesh, and greater stability is produced by passing the mixture through two subsequent mills.

The final mixture (50 per cent coal and 50 per cent oil) has a specific gravity of 1.09 and a ton occupies about 33 cu ft. With coal of 14,360 Btu and oil of 19,373 Btu per lb the calorific value of the product is 16,866 Btu per lb. In firing it is preheated to 200 F, for best results, and is pumped to the burners under 15 to 20 lb per sq in. pressure. It is said to be stable for a period of four months at normal temperature and twelve months if stored in sealed containers.

High Rates of Burning Lignite

Due to the large lignite resources in Germany which are utilized to a large extent in power plants erected adjacent to the lignite beds special attention has been paid to the development of lignite stokers. In the February issue of *Engineering and Boiler House Review*, Dipl. Ing. D. W. Rudorff describes one of the latest types of German lignite stokers which, despite the high moisture content of the fuel (over 50 per cent) has made possible high rates of burning at high efficiency.



Over-feed stoker with advance grate

This stoker is of the inclined over-feed double-grate type which incorporates an "advance" grate from which the distilled gases enter the furnace proper through arches above the grate and mix in the furnace with the gases from the main grate. High CO_2 is thereby attainable.

The illustration shows one of these stokers installed under a 14,500 sq ft boiler at the Finkenheerd power plant, test performance of which is as follows:

Lb of steam per hr	39,200	113,000	179,000	228,000
Coal per sq ft, lb per hr	13.51	43.2	72.6	101.73
Analyses of fuel				
Moisture, per cent	82.35	51.41	51.49	51.85
Ash, per cent	5.35	7.29	6.56	6.52
Heating value, Btu per lb	4197	4007	4111	4032
Boiler efficiency,[1] per cent	85	88.75	83.75	78.25

[1] This is probably on an "ash and moisture free" basis, following Continental practice, although not so reported.—Editor

Pulverized Fuel Firing in Great Britain

Reviewing the status of pulverized fuel firing in Great Britain, the January issue of *The Fuel Economist* (London) states that during the past six years there have been fundamental changes in the economic conditions which originally favored pulverized fuel firing. Chief among these has been the development of large and efficient mechanical stokers commensurate with the capacity of large modern boilers. Furthermore, these stokers have been designed to utilize low-grade coals which has had an important effect on the coal market. The increased demand for low-grade stacks has influenced prices and has retarded coal cleaning and grading. The growth in electric generation has been so rapid that many of those stations located at or near coal fields with the object of burning cheap low-grade coal are now finding that their coal consumption threatens to exceed the supply on which their economic basis was originally founded. Probably the most serious handicap under which pulverized coal firing has had to labor, however, has been the public campaign against chimney emission.

The opinion is expressed that pulverized fuel firing must now base its claims on operating efficiency and maintenance as the margin on initial fuel costs formerly available to cover the cost of preparation is shrinking and will tend to disappear.

Despite this, in the many stations now undergoing extension pulverized fuel firing appears to be holding its prestige for the large boiler units and also where this was the original system installed, although stokers are being employed in several of the new stations and some have both systems.

Combustion Control Tests

At the Pruszhov Power Station of the Warsaw Electricity Works a 12-hr test was run on three boilers with and without automatic combustion control. The results are reported in the February issue of *Engineering Progress* (published by the Verein deutscher Ingenieure, Berlin) as follows:

	With Control	Without Control
Duration of test, hr	12	12
Pounds of coal fired	81,950	83,750
Pounds of water evaporated	593,000	573,000
Evap. per lb of coal	7.22	6.84

The combustion control has been found especially advantageous at light loads and has permitted all six boilers in the plant to be kept on the line economically during the night shift and thus avoid banking losses. With full load on the boilers the improvement in efficiency was less marked although the whole series of consecutive tests gave a mean coal saving, attributable to the combustion control, of 4 per cent.

Handling Sludge Cake at the Battersea Station

In connection with the gas washing system at the Battersea Station it was found that the large amount of mud contained in the washing water from the Thames, when combined with the sludge, was at first difficult to handle. How this problem has been met was described in a recent paper by Messrs. Cullen and Durant before the Institution of Chemical Engineers (Great Britain) and referred to in the February issue of *The Power Engineer*.

The sludge is dewatered upon a rotary filter composed of cast segments each of which is covered with a resilient pad of spongy rubber encased in jute bagging. Each segment forming part of the peripheral filter surface is an independent element whose eduction pipe connects, by means of a central valve, with a wet vacuum pump. Half of the filter is immersed concentrically, with the larger clearance on the entrance side. As the filter revolves the cake is progressively built up on the lower segments and its tenacity permits it being lifted from the segments as it passes over a small roller near the apron after it has passed through nearly 360 deg.

The removal of the cake is automatically followed by the reversal washing of the filter cloth, the wash water also displacing air from the chamber to the atmosphere. The elements then commence a fresh revolution and cycle of operation.

Large Boilers Ordered for Australian Power Station

The East Perth Station, the largest steam generating plant in Western Australia, is to be extended by the addition of three 135,000 lb per hr, 675-lb pressure boilers fired by pulverized coal, also new turbine-generators and electrical equipment. The steam-generating and fuel-burning equipment has been ordered from International Combustion Ltd. and the turbines will be supplied by C. A. Parsons Co. and Metropolitan Vickers Ltd., respectively, according to the February issue of *The Fuel Economist* (London).

The coal burned at this station is of the semi-lignite type, brought from coal fields 120 miles from the station, and runs very high in moisture. In the original part of the station it is burned on stokers of the chain grate and inclined grate types.

Effect of Present Conditions on Power Plant Improvements

A Communication from HARVEY B. MANN, Vice President, of the Dravo-Doyle Company, Pittsburgh

The chief engineer who wishes to reduce his operating costs and the salesman looking for business can profit by analyzing the effect on their problems of public questions and political action about which they read almost daily.

Political action is responsible for greatly increased labor costs. The Code of the coal industry has curbed abuses and suicidal competition, resulting in much higher coal prices. Improvements which showed only a fair return upon the cost two years ago will under today's conditions yield a fine return. It is a good time to review some of those shelved schemes. The pressure to employ less labor and burn less fuel is bound to accelerate reequipment in such lines as coal handling, stokers and combustion control. Modernization of plants by the use of high pressure steam and bleeder or back pressure turbines is more easily justified.

High labor costs are especially noticeable in maintenance. Repairs and replacement parts are expensive and the cost of installation is all expensive labor. Therefore, the operator should pay especial attention to replacing equipment on which maintenance is high and in selecting new equipment on which it will be low. This factor has been important lately in the purchase of stokers and the use of more "black surface" in boiler furnaces.

Corporations formerly received three, four or more per cent interest on their bank deposits. Now the banks cannot use the money and will pay little or no interest on deposits. It is therefor more profitable than ever before to put that money to work in the owner's power plant. Many companies, although showing deficits, have been improving their cash balances. This is because depreciation is charged off before earnings are shown. This depreciation charge is capital and should be used to improve the property or to pay off capital obligations. It is therefore available in many cases to make improvements and replace wasteful equipment.

The pressure to reduce power rates has already borne fruit and will bear more. The Government sponsorship of low price electric appliances is getting under way. The lamp manufacturers have started a better lighting campaign which will have a considerable effect and is a great public service. All these factors will shortly result in a large increase in electric current production. In spite of hydro-electric development we will soon see renewed building of central-station steam plants.

Shorter hours and more leisure time will affect various industries such as automobiles, auto accessories, tires, printing and paper making. Breweries should also benefit. Some of these industries are already a good market for fuel- and labor-saving equipment.

After labor has satisfied its automotive needs, the clothing, shoe, and housefurnishing manufacturers will benefit and we can look for power equipment business in those industries.

At last, due to the Code benefits, the coal mining industry is beginning to do more than just keep going. It promises to have some capital to invest. Here is an over-ripe market for steam generating plants. When they can be financed, many such plants which will "pay out" in from four to eight years will be purchased.

The drive against utility holding companies will likely cause some decentralization. This has occurred to some extent in manufacturing. It has a tonic effect in the power plant. The "Chief" does not have so far to go to get action, and he gets more and better attention from the equipment engineers.

Legal limitations on boiler pressure due to age and design has resulted in considerable boiler business. This will be an increasing factor and with better earnings the owners will do a lot more to

modernize along with the boiler replacement. Engineers can see these replacements coming and have an excellent chance to work up all the plans for making the new job efficient.

After considering these elements which will facilitate expenditures for plant improvement it may be well to examine how to find where economies may be effected.

A large part of our wastes are due to not knowing they exist or that there is a better method or machine available. We are too near the forest to see the trees. Many of our bad practices are habits we do not stop to examine. If all engineers were moved to other plants, all would probably make some improvements. Some would make many. Or if chief engineers would welcome competent sales engineers to go over their plants in detail with them, similar results would be achieved.

Some good illustrations of these overlooked wastes resulted from an effort to discover some business in 1933. We checked all inquiries for pump repairs coming into the office. We prepared a list of all pumps sold from 1910 to 1925 with their efficiencies. Many customers wanted to repair obsolete pumps. The impeller one ordered cost $250. The new pump we persuaded him to buy instead cost $650. On the extra cost of $400 we saved $95 per month in reduced power consumption.

Among the old installations I noted a paper mill running a pump which had a designed efficiency of 68 per cent. A modern unit would operate at 83 per cent. Although their power from 600 lb pressure boilers and bleeder turbines cost only 2 mills, they saved the cost of the new pump in one year.

In two cases a field check-up showed such wide differences between operating conditions and those for which the pumps were originally purchased that three new pumps were justified and bought. These were for large corporations having excellent engineering departments.

A master mechanic requisitioned a new rotor. We found it was for an obsolete pump. Our investigation resulted in the purchase of a new pump at a great power saving for the customer.

Our list revealed a plant only thirteen years old having four turbine-driven boiler feed pumps. We saw the power engineer and found they had a surplus of exhaust steam. By adding a few nozzles to the turbine and increasing the speed, we could drive a pump of twice the capacity and at greatly improved efficiency. The steam saving over two of the old pumps at 20 cents per 1000 lb. is $4187 per year and the cost of new pump and reconditioned turbine was less than half that amount.

All that was just pumps in one small district. So there is no question that possibilities for big returns on plant investments are widespread.

Conditions for making plant improvements where the money is available, are approaching the ideal due to high labor costs, low money costs and abnormal obsolescence. Alertness on the part of plant engineers, sales engineers and sales managers will be rewarded.

Distribution of Coal Used

According to statistics collected by the U. S. Bureau of Mines, in collaboration with other agencies, the bituminous coal consumed during December 1934 was distributed as follows: electric utilities 12 per cent, by-product coke ovens 15.35 per cent, beehive coke ovens 0.59 per cent, steel and rolling mills 4.14 per cent, coal-gas retorts 0.93 per cent, cement mills 0.79 per cent, other industrials 36.40 per cent, and railroads 29.8 per cent. Obviously, these percentages will vary from month to month and may be materially altered by marked activity in any one of the major industries, but the foregoing is fairly representative of the relative order of these classes of industry as consumers of coal.

BOOKS

1—Air Conditioning and Ozone Facts

By E. W. Riesbeck

383 pages   5-1/2 × 8   Price $3.50

Here is a book written in non-technical language so that anyone wishing to familiarize himself with air conditioning and related subjects, such as refrigeration, cold storage plant operation, the use of ozone, and the sterilization of water, may gain a thorough understanding of these important subjects.

This book is also intended to furnish information to all those engaged in air conditioning work or plant operation seeking facts and figures on what may be accomplished with air conditioning in homes, offices, restaurants, hotels, hospitals, theaters, workshops, garages, cold storage plants and many other establishments.

Tables and information in this volume are based on practical experience and research work covering a period of many years.

2—Diesel Engine Design

By Harold F. Shepherd

227 pages   5-3/4 × 9-1/4   Price $3.50

A sound technical exposition of the various ways of converting petroleum fuel into power by the compression ignition method. This book includes a straightforward, practical discussion of design parts and test results. One of its outstanding features is its logical statement of the merits and useful ranges of other engines as opposed to the diesel type.

3—Draft and Capacity of Chimneys

By J. G. Mingle

339 pages   Illustrated   Price $3.50

The subject matter of this book has been developed primarily from a theoretical standpoint and then amplified by experimental data gleaned from actual practice.

The author observes that draft, even to the expert, frequently contains an element of mystery, and that there is often a great deal of confusion and misconception on the subject. A careful study of this book will give a thorough and practical knowledge of this important subject. The book is profusely illustrated with graphs and charts. Many valuable tables are included and the index has been prepared for ready reference.

4—The Chemical Formulary Volumes I and II

600 pages   5-1/2 × 8-1/2   Price $6.00
570 pages   5-1/2 × 8-1/2   Price $6.00

Chemists, engineers, technical workers, purchasing agents, executives, instructors, etc., will find this condensed collection of valuable, timely and practical formulas for making thousands of products in all fields of industry of great assistance. It bridges the gap between theory and practice. More than two hundred industrial chemists, professors and technicians in many branches of industry have cooperated to make this the most modern work of its kind available.

Vol. I of *The Chemical Formulary* was published in 1934. Vol II, just published, supplements the former volume and brings it up to date. This new volume covers the entire field of practical chemical compounding. It is entirely new and not a revised edition. Not one formula that occurs in Vol. I is repeated in Vol. II.

The Chemical Formulary, Vols. I and II, contains methods for making:

Abrasives, Adhesives, Alloys, Anti-freezes, Anti-corrosives, Artificial Rubber, Artificial Stone, Artificial Leather, Automobile Specialties, Boiler Compounds, Candles, Carbon Paper, Celluloid, Cement, Cement Water-proofing, Chromium Plating, Cleaning Compounds, Concrete Specialties, Cork Compositions, Cutting Oils, Disinfectants, Driers (Paint) Dyeing, Explosives, Extracts, Fertilizers, Fire Extinguishers, Fireproof Paints, Flotation Agents, Fuels, Gems, Grease, Lubricating, Ink, Printing, Ink, Specialties, Insulation, Electrical, Japans, Lacquer, Leather Finishes, Lubricants, Metal Plating, Metal Polish, Molding Compounds, Oilskin, Paint, Acid Proof, Paint, Cold Water, Paint Remover, Paper & Pulp Specialties, Paper Coating Petroleum Specialties, Pigments, Plastics, Plasticizers, Refractories, Rubber Compounding, Rustproofing, Safety Glass, Shoe Dressings, Solidified Oils, Soluble Oils, Solvents, Stains, Wood, Stripping Solutions, Tanning, Varnish, Bakelite, Varnish Removers, Viscose Specialties, Vulcanization, Waterproofing, Wax Emulsions, Wood Filler, etc., etc.

5—Combustion in the Power Plant (A Coal Burner's Manual)

By T. A. Marsh

255 pages   Price $2.00

The author's discussion of coals and combustion is simple and understandable. His consideration of equipment—stokers, boilers, furnaces, fans and auxiliaries—is thoroughly practical. He tells how to select a stoker for the best available coal; how to design furnaces and arches; how to analyze draft problems and design chimneys, gas flues and boiler passes; how to purchase coal and calculate steam costs. He gives to every phase of his subject a practical interpretation that makes this book of exceptional value to men actually identified with steam plant design and operation.

6—Higher Mathematics for Engineers and Physicists

By I. S. and E. S. Sokolnikoff

482 pages   6 × 9   Price $4.00

Many engineers and research workers have to depend in the field of mathematics on books written primarily for students of mathematics, and are often bewildered by detailed analyses of certain topics which seem to them irrelevant and superfluous. This book bridges the gap which separates many engineers from mathematics, by giving them a bird's-eye view of those topics of mathematics which are indispensable in the study of physical sciences. The keynote is practical utility. Those topics have been selected which are of most frequent and immediate use in applied sciences. Statements are terse, pointed, clear diagrams or graphs are ample and helpful—uncommon pedagogic skill clarifies the more abstruse problems.

7—American Inventors

By C. J. Hylander

216 pages   5½ × 8 $2.00

Brief, entertaining sketches of the lives of nineteen well-known American inventors are contained in this book, which, although intended primarily for boys of a mechanical turn of mind, gives much information that is of interest and value to the maturer mind, particularly from a reference standpoint.

Among the inventors whose stories are told are Benjamin Franklin, John Fitch, Eli Whitney, Robert Fulton, Samuel F. B. Morse, John Ericsson, Charles Goodyear, Alexander Graham Bell, Thomas Alva Edison and Lee de Forest.

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NEW CATALOGS AND BULLETINS

Any of the following publications will be sent to you upon request. Address your request direct to the manufacturer and mention COMBUSTION Magazine

Aftercoolers

A new 12-page bulletin illustrating the various types of aftercoolers, for air or gas, made by Ingersoll-Rand Company, New York, is now being distributed by that company. It explains the reasons why aftercoolers are needed and how the various types fit into certain compressor plant conditions. The bulletin is fully illustrated.

Centrifugal Pumps

Worthington Pump and Machinery Corporation, Harrison, N. J., has added two larger units to its line of monobloc centrifugal pumps. These are of 3 and 4 in. sizes and are described in Bulletin W-321-B4.

Chains, Sprockets and Buckets

The C. O. Bartlett & Snow Company's bulletin No. 74, covering chains, sprockets and buckets, is available for distribution. Standard types of detachable, pintle, key bushed, combination, drag, roller, transfer, steel bushed and drop-forged chain and chain attachments are illustrated, and the dimensions, weights, working loads and prices are given for each size. Eighteen pages are devoted to listings of prices and weights of sprocket wheels. Desirable information is given with regard to sizes, prices, etc., of shafting, collars, takeups, elevator buckets and spur miter, and bevel gears.

Draft Control

Bulletin No. 2018 has been issued by The Hays Corporation, Michigan City, Ind., describing "Draftrol" gages for indicating and controlling draft, pressure or flow of gas or air. These gages combine an indicating draft gage of the pointer type with a draft controller and can be furnished with or without the indicating pointer or with one or two non-tilting mercury switches for either high or low voltage contact.

Engines

A 32-page bulletin covering steam engines and engine-generator units of the single-valve, four-valves, corliss and poppet-valve unaflow types has recently been issued by the Elliott Company, Pittsburgh, Pa.

Feedwater Regulator

A 16-page bulletin entitled "Bailey Feedwater Regulators" is being distributed by the Bailey Meter Company, Cleveland, O. It deals with thermo-hydraulic feedwater regulators, lists the distinctive features, illustrates the principle of operation by the thermo-hydraulic generator, and describes Bailey regulating valves of both the light-seating and the sleeve types. Data on excess pressure valves are included and a tabulation of valve dimensions is appended.

Feedwater Control

"The Men Behind Our Promises" is the title of a seventeen-page, elaborately prepared booklet dealing with the organization and facilities of the Hall Laboratories, Pittsburgh. Individual photographs of the personnel together with biographical sketches are included.

Furnace Linings and Arches

McLeod & Henry Company, Troy, N. Y., has just issued a 32-page catalog covering its "Steel Mixture" refractories, firebrick and cements. Applications to various types of settings, furnace walls, arches, blow-off pipe protection, etc., are described and illustrated in color. Useful engineering data are also included.

Meters

"Rotameters," for measuring boiler feed, chemicals fed into boiler feedwater, boiler blowdown, oil flow to bearings, cooling water to transformers and other equipment, are described in a new 18-page bulletin just issued by Schutte & Koerting Company of Philadelphia. Among the new developments covered are automatic flow proportioners, automatic flow controllers, flow alarms and several designs of direct indicating Rotameters. Understanding of the operation of these devices is facilitated by numerous drawings and diagrams in color.

Paint

An attractive bulletin just issued by the Quigley Company, New York, deals with the uses and application of Triple-A No. 44 aluminum coating. Typical applications in the power plant are illustrated and it is emphasized that this can be applied effectively on damp surfaces as well as dry.

Refractories

The General Refractories Company has just issued a series of ten bulletins covering its products and their fields of application. One of these deals with the company and its facilities; four deal, respectively, with fireclay brick, plastic firebrick, chrome-base high-temperature cement and fireclay and cyanite-base high-temperature cements; while the next four deal with the application of these products to boiler plants, metallurgical processes, oil refineries. The tenth bulletin is devoted to refractories produced in the South.

Simplified Boiler Control

Bulletin F-172-T, issued by Leeds & Northrup Company, Philadelphia, describes the new "Metermax" unit combustion control which is especially adapted to medium-size and small boilers. It is a development of the well-known L & N metered combustion control and maintains an air loading pressure in definite relation to steam demand, and balances against this pressure metered quantities of fuel and air to each boiler. It employs electricity as the power medium.

Speed Reducer

Recently off the press is a 20-page illustrated catalog No. 1515 by Link-Belt Company, Chicago, devoted to its newly developed line of motorized speed reducers, in which the motor is mounted directly on the side of the reducer housing, thus making a shaft coupling or a motor base plate unnecessary. It shows by means of an example how the proper reducer can be selected from the tables, which give dimensions, capacity ratings and speed ratios.

Stokers

A 16-page catalog, No. E-8, describing the well-known Type E, center-retort, underfeed stoker has just been issued by Combustion Engineering Company, New York. To date over eleven million square feet of boiler heating surface have been fired with this stoker, burning both caking and non-caking bituminous coals, as well as waste, solid fuels in combination with coal. The new catalog contains a very complete description of every phase of the stoker's construction, operation and control. An introductory chapter on the economics of buying a stoker and numerous diagrams showing typical ash pit and air duct arrangements, as well as applications to various types of boilers, have been included.

Valves

Homestead Valve Manufacturing Company, Coraopolis, Pa., has issued a 46-page illustrated reference catalog describing its complete line of valves including the newer products such as the protected-seat hydraulic operating valve and the protected-seat spray valve used in the control of high-pressure spray systems.

ADVERTISERS in this issue

ECPD Will Accredit Engineering Colleges

Approval of the Engineers' Council for Professional Development as the agency for accrediting engineering colleges was conferred by the American Institute of Electrical Engineers on January 21, 1935, thus completing the authorizations needed to inaugurate the accrediting procedure which has already been approved by the other participating bodies, namely the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, Society for the Promotion of Engineering Education and the National Council of State Boards of Engineering Examiners.

The purpose of E.C.P.D. is to substitute a single accrediting for the uncoordinated methods that have been used in the past. It is merely authorized by its constituent organizations to publish a list of accredited colleges and has no authority to impose any restrictions or standardizations upon engineering colleges. Appraisal of institutions will be based upon statistical information as obtained from catalogs and questionnaires, and upon evidence of quality of instruction, adequacy of equipment, and of teaching staff, and other factors not susceptible of statistical analysis, as determined by visits of inspection by committees of qualified representatives of the Committee on Engineering Schools. Emphasis will be given to quality of work rather than to statistical information to a greater degree than in former accrediting procedures.

Final decision as to accrediting of each institution rests with the Engineers' Council, which will pass upon the recommendations made to it by the Committee on Engineering Schools.

The general expenses of developing the accrediting program will be borne in part by a grant of funds from Engineering Foundation. Expenses of the visiting committees representing the Council will be met by a charge made to the individual institutions sufficient to cover cost of travel and subsistence during the inspection. Committees of inspection will comprise both teachers and practicing engineers, the criteria for selection being competency to judge educational institutions, good judgment, and availability.

The Committee comprises the following individuals:

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